PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY

OF

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1862-63—1865-66.

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PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

NINETY-SECOND SESSION, 1862-63.

Wednesday, 26th November 1862.—ALEXANDER BRYSON, Esq., President, in the Chair.

Major Frederick Roome, H.M. 10th Regiment, Bombay Native Infantry, and George W. Manson, Esq., H.M. Bengal Staff Corps, were elected Non-Resident Members of the Society.

New Parts of the Proceedings were laid on the table.

The following donations to the Library were laid on the table, and thanks voted to the donors:—

1. (1.) Transactions of the Royal Society of Edinburgh. Vol. xxii. Part 3., for the Session 1860-61. (2.) Proceedings of the Royal Society of Edinburgh, Session 1860-61—From the Society. 2. Proceedings of the Royal Society of London, Nos. 48-50—From the Society. 3. The Canadian Journal of Industry, Science, and Art. New Series. Nos. 38-41, March, May, July, and September 1862—From the Canadian Institute, Toronto.

Mr BRYSON then delivered the Opening Address:—

GENTLEMEN,—In opening this the ninety-second Session of the Royal Physical Society, permit me, as retiring President, to offer, in the first place, a few remarks on the Present Position of Mineralogy in regard to Physical Science.

The science of Geology, or the study of the past of our earth, naturally divides itself into three branches, Petralogy, Mineralogy, and Palæontology. The first concerns itself chiefly with the superposition and dynamic relations of the rocks and strata which compose the crust of our globe; while mineralogy is devoted to the chemical qualities of the

various minerals which compose entirely or are products of the rocks; palæontology, on the other hand, has only to do with the organisms so profusely found in the strata from the Azoic, through the whole range of the Palæozoic series.

Petralogy, which mainly studies the superposition and ages of rocks, has, since the days of Dr William Smith, received its principal facts from the labours of the palæontologist.

The balance of the mineralogist and his goniometer have, during those last fifty years, been sadly ignored and overlooked by the geologist, who is ever and anon boasting that he studies in the field, and has no faith in the teachings of mere hand specimens in the closet. That this is true, I quote from the first line of the first chapter of the last, and certainly the best book lately published on the subject, namely, "Jukes' Manual of Geology," where he states,—"Lithology, or the study of the mineral structure of rocks, is based on mineralogy. . . . In order to understand lithology, however, an acquaintance with mineralogy in general, though always useful, is by no means necessary, since the minerals which enter into the composition of rocks are very few compared with the whole number of minerals. But as regards these few minerals, it is their chemical composition, still more than their physical characters, which we have to regard in their lithological relations. It is therefore absolutely necessary to understand so much of chemical nomenclature and chemical laws, as shall enable us clearly to comprehend the precise meaning of this chemical composition.

"As, however, geologists, from the very nature of their pursuits, are unable to devote much of their time to closet study or laboratory work, unless at the expense of their own more proper field of investigation, I will here endeavour to assist the student by giving him a condensed abstract of so much of the elements of chemical mineralogy, as may enable him to understand rightly the lithological descriptions which follow." The reader of this most admirable work will find this sentence, which I now quote as germane to our subject, in page 8 of the introduction, and which,

in our humble opinion, ought to have been the conclusion of the paragraph now read,—"Practically," says Mr Jukes, "it has been found, that while a very slight acquaintance with the most ordinary forms of some ten or a dozen of the most frequently occurring minerals is all that a geologist must *inevitably* learn of mineralogy, the number of fossil animals and plants, with the forms and the names of which he will have to make himself familiar, will often have to be reckoned by hundreds."

"This branch of geological knowledge is now known under the name of Palæontology. Perhaps, however, the tendency of late years has been to neglect to too great an extent the bearing of mineralogical knowledge on geology. There are many subjects on which we have still to ask the chemist and mineralogist to enlighten us."

"One deficiency which is particularly obvious in Britain is the want of a good and precise nomenclature of rocks, and especially of igneous rocks. Since the publication of Jameson and Macculloch, no attempt has been made to supply this deficiency, and to bring up our lithological nomenclature to the present state of chemical and mineralogical knowledge."

Let us now attempt to trace the causes which have produced this carelessness on the part of the English School of Geology in regard to mineralogy, and to point out how much we have lost by their ignorance of so important a section of our science. That mineralogy is based on chemistry, no one who now hears me is likely to dispute; and no one who does not know the elements of mineralogy is, on the authority I have quoted, fitted to be a geologist. It is only on the extent of that knowledge that I would beg to differ from the director of the Irish Geological Survey, and his distinguished coadjutors in Jermyn Street.

Many reasons are apparent why mineralogy should have sunk to so low a level, as that, among the qualifications of a student of geology, the mere apprehension of the characters of a dozen simple minerals should fit him for the herculean task of becoming an accomplished geologist.

Perhaps among the first causes which put mineralogy out

of the geological curriculum, was the very early introduction of the elaborate and abstruse methods of crystallography. This section of mineralogy was principally studied in Germany, where Mohs and Haidinger rank as its most distinguished cultivators, and to whose labours we owe the best treatises on crystallography. But while they were measuring minute angles, and carefully comparing them with the analysis of the chemist, they had seemingly no interest in the questions which are asked at this time, How were these minerals imported, if I may use the term, into those rocks, which are the peculiar study of the dynamic geologist? The mineralogists hence became mere collectors of rare specimens, boasting themselves of the possession of one or more rarities, quite forgetting that the analysis and structure of these precious things were connected intimately with the theory of the rock masses in which they were found embedded.

Another cause is not difficult to trace in regard to the obstinate rejection of mineralogy by the Nestors of English geology. They mostly took up the subject late in life, without any initiation into the relations of minerals to rocks, and finding that they were acquiring fame and honours by the mere study of superposition, as indicated by palæontology, have devoted all their labours to this branch of the subject. They have, indeed, been fortunate in the selection of their coadjutors: Owen and Huxley, as comparative anatomists, Brown and Brongniart as fossil phytologists, Sowerby, and Morris, and Davidson, have done good service as conchologists, while Bowerbank and the lamented Professor Quekett have added many new facts to microscopic palæontology. Nor ought we to forget what Hopkins, Phillip, and Symonds have done in the dynamics of geology.

But while we have seen great and good work done by all these able men, and many more we could name, we have very few who are striving to unite the great sections of the science of mineralogy with geology proper. Yet the day seems dawning when we may expect rich fruits from this hitherto uncultivated field. I shall now endeavour to show shortly

how many and important are the questions which the mineralogist has to answer, and also attempt to prove the truth of my first proposition, that geology is based on mineralogy, instead of being merely an adjunct.

I have shown, in a paper which I had the honour of reading to the Royal Society, that the great fundamental granite is most probably of aqueous instead of igneous origin. Now, this very question is much more one to be answered by the mineralogist than the geologist. He may indeed boast that it was in the field at Glen Tilt that Hutton found the intrusion of the granite into the stratified schists; but it was to the laboratory of Hall, and to his crucibles, that our Nestors owe their theory of the igneous origin of these rocks.

Is it not, however, strange that men, who boast of their field work so much, should have failed to see that the junction of granites with schists, and also the union of granites themselves, should so rarely show any symptoms, however slight, of any alteration or metamorphosis at the connecting edges? It seems as if men, when they have accepted a theory, adopt the simple plan of never looking at any fact which may militate against it, and so from teacher it passes to pupil, and, without hesitation, is adopted as a simple faith, and all those who attempt to doubt or disprove it are charged with heresy. When at the late meeting of the British Association at Manchester, I took the opportunity of urging these views of the aqueous origin of granite; and although supported by the whole of the younger chemists and mineralogists, I was opposed by the venerable Dr Daubeny of Oxford, by the remark, "That though my theory seemed very ingenious, and he was not prepared to advance any argument against it, he hoped that from his age he would be allowed to maintain his old faith."

Before passing from this question of the aqueous origin of granite, allow me to give you the last proof which I have discovered of the truth of the theory.

It is well known that brown quartz, which occurs so abundantly in our Scottish granites, to which the name of Cairngorm has been applied, from being first found on that mountain, owes its brown and sometimes yellow tint to the

presence of bituminous matter. If a section of a crystal of brown quartz be placed under the microscope, many fluid cavities may be observed; but if we expose it to a temperature equivalent to that of iron at a dull red heat, we find that not only have these cavities been emptied of their fluid contents, but the colour has also been discharged. Now this very curious fact has been long taken advantage of by the jewellers in decolorizing specimens of brown quartz from Cairngorm, which were too dark for their purpose. How then can we suppose this brown quartz to have retained its bitumen under such a fiery ordeal as we are led to believe the granite which envelops it has undergone? When we ask the question, we are very coolly informed by the advocates of Plutonism, that the granite was then under immense pressure, by means of which not only the fluid contents of the cavities, but the bitumen was retained. Had these gentlemen given any attention to mineralogy, they would soon be convinced that in this instance at least, the argument was vain, as in all cases where the crystals of brown quartz are found they occupy large cavities in the granite, a condition not likely to obtain under such immense pressure as they assume. Another observation confirmatory of these views has been made by a young chemist, Mr Scott of Dublin, who has shown that felspars, in many of the Irish granites, are decomposed at low temperatures, and could not have existed in their present chemical conditions under great heat. The most sincere Plutonists are now wavering in their opinion regarding the high temperatures to which the primary rocks were exposed; even the experiment of Hall, of converting chips of limestone into marble under great heat and pressure, is now, if not entirely ignored, greatly doubted, and the Museum of the Royal Society cannot clear up the mystery, as no specimens of Hall's have been conserved. Even the first discovery of Hutton, of the intruding granite at Glen Tilt, has been pushed aside as useless by the present writers on the igneous origin of the primary rocks. This opinion is strongly expressed by the Rev. Vernon Harcourt, who, in a report made to the British Association in 1860, on the effects of long con-

tinued heat on metals and minerals, says—"The crystallization of the primary rocks was supposed by the early Plutonic theorists to be due to *slow cooling;* but this principle alone does not satisfy the phenomena. The crystalline structure of granite is seen, for example, in Glen Tilt, at Shap Fell and elsewhere, to be equally uniform in its partial irruptions into the superior strata, as where it appears to be the foundation-stone of the earth's crust it has crystallized in its accustomed manner, where it has penetrated fissures of the upper beds in plates as thin as the leaves of a book, and threads as fine as a hair; and even where it is involved in the invaded *stratum*, so that no junction with any vein can be observed. How could it have been thus injected in a state of fusion unless of the most liquid kind? and how could the heat of such liquidity, in a material of which the fusing point is so high, be otherwise than *rapidly* cooled down?" Yet this difficulty does not prevent the reverend gentleman from still believing that the granite was of igneous origin, and persists in his belief in the face of the fact, that "the quartz which forms so large a constituent of granite has always the specific gravity of *crystalline* silica, which exceeds that of any other species of silica; and Deville and others have shown that *fusion lowers* this specific gravity to a constant amount, and that *fused* silica does not recover its density in cooling. Crystalline granite, as Delesse has shown, passes by fusion from the density of 2·62 to that of 2·32, and Egyptian porphyry from 2·76 to 2·48."

The Plutonists, in their anxiety to maintain the old doctrine of internal heat, have not, in my opinion, improved their position by discovering that the ramified granite of Glen Tilt and Shap Fell is similarly crystallised with the rest of the rock, but only finer grained; nor has the experiment of Mr Marshall, who fused a large mass of granite, and having slowly cooled it, failed to obtain crystals, aided their hypothesis.

If the experiments of Hall were correct, and the speculations of Hutton true, we ought to find, wherever the granites are intruded, metamorphic changes due to heat made

apparent. But these phenomena are seldom seen, except when found by those desirous to support their Plutonic views, a race of philosophers by no means rare, and who, I am sorry to say, are now occupying the highest places in the science. Formerly these gentlemen asserted that the granite crystallised by slow cooling; now it is found that this doctrine is untenable, and it must have crystallised by rapid cooling. If this latter view is correct, I ask the supporters of the hypothesis how they explain the fact that the lowest granite differs in no mineralogical character from the uppermost peak of the Himalaya mountains? Surely the lowest portions of those great ribs on which the foundations of our fair earth were built must have been more highly molten, being so much nearer to their favourite central heat than the upper ranges, and therefore more slowly cooled. By the first view (that is Hutton and Hall's), the lower layer of granite should be more crystalline than the upper, *but it is not so.* By the more recent theories of Harcourt and others, the upper layer ought to be the more crystalline; *but it is not so*,—and on the horns of this dilemma I leave the supporters of Hall, Hutton, and Harcourt.

The last two dogmas of the new school of geologists are contained in the following words, which I quote from the Rev. Vernon Harcourt's report:—

1st, "All the consolidated strata, viewed chemically, bear marks of subjection to an action of heat agreeable to the theory of the earth's refrigeration in direct proportion to the age of their deposit; and that they show that action most explicitly in the presence throughout, but more abundantly as the series descends, of that peculiar form of silica which is chemically reproduced by the action of heated volatile matter.

2d, "That the igneous minerals were formed by molecular aggregation at a heat not exceeding perhaps that of an ordinary fire, either as a residuum from the expiration of fusible and volatile materials, or more generally as a deposit from volatile forms of matter."

These seem very heavy dogmas to deal with; but before accepting them, it is the duty of every mineralogist and geologist to test them before adoption as a part of their

faith; for my own part, I have never hesitated to question a dogma from a divine if I thought he was wrong in his theology, and have now none in trying to refute these statements, believing, as I do, that geology is a science of facts, not of faith. Let us consider his first statement, "That all the consolidated strata, viewed chemically, bear marks of the subjection to an action of heat agreeable to the theory of the earth's refrigeration in direct proportion to the age of their deposit." Where the Rev. Mr Harcourt finds proof for this statement I have failed to see in his report. If he believes, as most geologists do, that the granite is the lowest rock we know in the crust of the earth, why can he not show the marks which bear evidence of greater chemical action at the base than is borne at the summit of the formation? As I have said before, not being able to see any difference, mineralogically or chemically, in the structure of granite, I am therefore bound to reject this portion of the statement. And now with regard to the second half of his first proposition, which states "That they [the rocks] show that action [*meaning heat, or chemical action due to heat*] most explicitly in the presence throughout, but more abundantly as the series descends, of that peculiar form of silica which is chemically reproduced by the action of heated volatile matter." Now, in dealing with this latter statement, I feel at a loss to see for one moment how the granites, the gneiss, and schist, and greywackes, bear evidence of being exposed to greater heat than we find exhibited in the Carboniferous epoch.

I have already shown in my paper on the Aqueous Origin of Granite, that there, and also in traps, cavities exist, containing fluids which entirely fill the spaces at a temperature not higher than 94° of Fahrenheit, demonstrating that those cavities could not have been filled at a higher temperature. With this fact, along with others I have mentioned, I cannot accept the latter portion of Harcourt's dogma. And I now beg you to remark, that the first dogma relates to the consolidated strata, the second only to igneous minerals; let me repeat it: "The igneous minerals were formed by molecular aggregation at a heat not exceeding,

perhaps, that of an ordinary fire, either as a residuum from the expiration of fusible and volatile materials, or more generally as a deposit from volatile forms of matter." This statement is by no means liable to so many objections as the first. During a visit which I made to Vesuvius during the famous eruption of 1857, I was much struck with the fact that no minerals could be obtained from the recently ejected lava, while they could be obtained readily in the more ancient ejections which form Monte Somma. This gives great probability to the suggestion, that the minerals found in lavas and other igneous products were due to a residual, molecular, and segregatory action after the mass was in fusion; and the same evidence I saw in the recent lavas of Iceland in my visit during last summer. But that even the heat of a common fire was essential for the metamorphism, I cannot believe. You are all aware that Pompeii was destroyed by hot ashes from Vesuvius, as so vividly described by the younger Pliny; and that Herculaneum was overthrown by hot mud. Now, between the pillars of the stage of the theatre at Herculaneum I extracted from the hardened mud crystals of augite, which all the Plutonists affirm is of igneous origin, but which must have been subsequently formed after the deposit of the mud in the matrix, and at natural temperatures, thus proving to me that augite may be formed from volcanic eruptions after the liquid, not by the fusible method, and that at a temperature not greater than normally obtains.

From these few and desultory remarks I have attempted to indicate that mineralogy should take no unimportant place in the curriculum of a geologist. Permit me now to give a few general observations on the phenomena most interesting to a mineralogist and geologist in a trip to Iceland, more especially as they bear on our present subject. The principal object I had in view in my journey to Faröe and Iceland was to study the appearance of rocks of known igneous origin, so as to compare them with those of our own country, which are only believed to be of Plutonic origin. It is very difficult for any geologist to look at any phenomenon without a leaning to some favourite theory. This I

was determined, as far as possible, to avoid, and very early in my diary I find written, "I now give up every theory, and vow only to look at facts." This sentence was written, however, in presence of Bjarnarey, one of the Westmanna Islands, where the contortions of the tuffa were so puzzling that I was unable to form a theory, so I take little credit for this seeming impartiality. On approaching the Faröe Islands one is struck by the grandeur and stateliness with which they rise perpendicularly from the sea, and also with their similarity to many of our own Hebrides. The amygdaloidal traps alternate with the softer tuffa, precisely as we see them at the Storr and Quirang in Skye. On arriving at Thorshavn, the port and capital of the islands, my first object was to obtain evidence of the supposed glacial action which had ground and polished many surfaces of rock near to the town. I had little difficulty in finding indications there attributed to northern drift and glacial action, but unfortunately they proved to be another instance of the difficulty of ridding ourselves of long-cherished views. These striated surfaces lie at a very small angle to the horizon; they are smooth, parallel, and regular, and altogether unlike any dressed surfaces I had yet seen. On picking away the moss and earth from the base of a cyclopean stone which lay immediately above the ground surfaces, and which was evidently *in situ*, I found that the grooves extended below the moss, and further, that its perpendicular and exposed surface was untouched; the conclusion was therefore forced upon us that they were merely slickensides grooves caused by the near contact of two rock surfaces, and therefore yielding no proof of drift or glacial action. And while on this subject, permit me to state, that from the fact of no drift having been found either in Iceland or the Faröes, and no dressed or grooved surfaces other than those due to modern glaciers, I have taken up the idea, which I hope either to prove or abandon on a subsequent visit, that instead of these islands bearing evidence of the drift, that their sudden upheaval was the cause of this hitherto unexplained phenomena.

Another point of considerable interest presented itself in the great abundance of calcedony and zeolites in the cavities

of the traps of Faröe, and which to me were instructive, as an indication of the method by which these immense trappean beds were deposited. It has been admitted by most mineralogists that calcedony is formed by the aqueous method, and not subjected to any violent heat; so here we have a proof, that the matrix or trap was not exposed to igneous fusion, and that the calcedonies and zeolites were metamorphic after the deposition of the trap. That these immense beds were of volcanic origin, no one will be bold enough to deny; that they were subaqueous I cannot doubt, by the evidence they bear of having been horizontally arranged by water, and that, while at a comparatively high temperature, they were subjected to the action of gases under great tension, causing the vesicular cavities which are now filled with calcedonies and zeolites,—the evidence of long continued metamorphism. That these islands have risen at a period when the upper layers were still, if not plastic, yet containing much volatile matter, is evident from the columnar effects seen on all their summits, caused, certainly, not by igneous crystallisation but merely shrinkage. These pillars are always, as has been often pointed out to us by our late distinguished President, Professor Fleming, at right angles to the strata beneath.

The first glimpse of Iceland, to one who has from boyhood made it his hope and day-dream to visit it, was certainly very grand and impressive, as our eyes rested on the magnificent Oraefa Yökul, the highest mountain in the island. But as our aim was more scientific than scenic, we were more interested, as we approached the great chasm or crater of Kötlugja, which so lately as 1860 devastated the whole country around with a deluge of mud and showers of ashes. This enormous rent, which we reckoned equal to the whole length of Glen Rosa in Arran, is evidently so steep, that the snow does not lie on its sides, and there it stands in gloomy grandeur, on the haunch of an immense ice mountain, the Myrdals Yökul. Skirting the shore, we were much gratified by the sight of one of the largest glaciers in the plain, and, as we commanded the whole position, had a finer opportunity than we ever enjoyed in Switzerland, of observing the

peculiar and beautiful effects of the construction of a glacier in its descent towards the sea. Above, all is smooth and far spread out; a little lower down, it becomes more crumpled up as the space becomes more limited, and you can see that the point of maximum motion is in the centre. Further down, the crumpling is increased, until, before it reaches its destination, the crumples have become ten thousand spikes, which, seen under a meridian sun, and with the help of good telescopes, appeared as if the bayonets of ten thousand soldiers were raised on high, and ready to be lowered to oppose an equal host.

I shall now only allude to one or two points of interest in regard to the lavas of Iceland which are germane to our present subject, leaving the description of the Geysers, and their mineralogical and chemical teachings, to another time, when I hope to take the opportunity of showing how many questions they may solve in geology which hitherto have been unanswered.

The geologist, on first setting foot on Iceland, is at once struck with the certainty that all has been of volcanic origin: black ashes, bleak mountain ranges, and rude irregularity of surface, convince him that not long back in the geologic record, this Haven of Reykjavik was surrounded by the most violent eruptions of fire. But as he journeys towards the interior of the island, he finds that he can differentiate at once between the outpourings of lava as it flowed molten from the crater, and those other formations which were truly subaqueous.

As my attention was particularly directed to the appearance of subaqueous formations, in the hope of detecting dressed surfaces, which would be geological chronometers to indicate the age of irruptions, in which I failed; I was led to remark how very easily one may be led astray by finding so many parallel and comparatively smooth surfaces lying close in contact with many tortuous shapes. After a careful examination of many hundred instances,—for they are the most common phenomena in the journey to the Geysers,—though curiously overlooked by former travellers, I was led to the conclusion, that they were merely plications or folds in the

lavas, during their molten and plastic condition, and were no evidence of dressing.

These plications are very curious, and exist only on the top of domes, or blisters in the lava streams. They present most beautiful curves, starting from the centre of the dome, and often at the edges becoming straight and parallel, and, when found broken up and separated from the tortuous portions, might readily be mistaken for either slickensides or glacial grooving. Below these plications, which are seldom deeper than an inch, may be seen the rude basaltic form of the lava arranging itself by shrinkage, by a slower cooling process than the plicated surface above. Some idea may be formed of the size of these blisters in the lavas, when I tell you, that at Surtseller they are from 60 to 100 feet in diameter. These blisters are mostly covered by the domes, and as the horses' feet clatter over them, you can hear the deep hollow sound echoed from below. One dome had fallen in, and we gazed with awe and wonder down a cone as large as any of those erected for the bottle-works at Leith. Its interior surface had a most peculiar jagged appearance, caused by the lava cooling in long drooping spikes. As at Vesuvius, I could not find the slightest trace of a mineral among the recent lavas, while the more ancient were filled with zeolites and calcedony, another proof to me that a subaqueous volcanic deposit (subsequently elevated) is the true matrix of our simple minerals.

In conclusion, allow me to congratulate you on the labours of the last Session, and with the hope that, under the distinguished Presidents now in office, we shall be able, at the conclusion of this Session, to present as goodly an array of papers as we have had during the past.

Dr M'Bain, seconded by Mr J. M. Mitchell, moved a vote of thanks to Mr Bryson for his learned and interesting address, and for his valuable services while president of the Society.

The motion was unanimously agreed to.

The following Communications were then read:—

I. *Analysis of the Discoveries on the East Coast of Greenland, bearing on the Site of the East and West Bygds, and on the connection of Scoresby's Sound and Jacob's Bight; with a Plan of Renewed Exploration.* By ROBERT BROWN, Esq., Botanist to the British Columbia Expedition.

In this paper the author reviewed the early history of Greenland, the state of the ancient Scandinavian colonies, and the different expeditions sent in search of them; and brought forward a number of facts to prove in opposition to the opinions of Eggers, Graah, and most modern geographers, that there is not yet sufficient ground to doubt the testimony of the ancient historians, that the colonies existed not only on the *Vester* but also on the *Æester Bygds*, and the probabilities are, that under more favourable circumstances than the imperfect expedition of Graah met with, remains will yet be found. He concluded by laying before the Society a plan of a new expedition by means of reindeer sledges conjoined with boats, for the settlement of this and the disputed point regarding the connection of Jacob's Bight on the west coast, and Scoresby's Sound, or some of the inlets in the vicinity, on the east coast, regarding which an almost certainty exists; and by which the geography of the east coast, from Cape Dan to Cape Barclay, will be explored.

II. *On some Species of* Hæmatopinus *parasitic on the* Pinnipedia. By ROBERT BROWN, Esq.

Three species were described found by the author in Davis' Strait and Baffin's Bay (Sea), during the summer of 1861. (1.) *Pediculus Phocæ* (Lucas, in Guerinz. Mag. Zool.), *Hæmatopinus setosus*, Burm. On the belly of the "Saddleback seal" (*Calcocephalus Grœnlandicus*, Mull.) (2d coat). (2.) On the body of the Walrus (*Trichecus rosmarus*, Linn.) (3.) At the base of the mystachial bristles of the Walrus.

Mr GEORGE LOGAN, W.S., laid before the meeting a notice of the Entomological Collections of the late Mr Curtis, the British portion of which is especially valuable, as containing the typical specimens figured in his great work illustrating the genera of British insects; as well as a valuable collection of economic entomology, illustrative of insects destructive to farm produce, garden crops, timber, trees, &c. These, along with his extensive entomological library, and the original drawings from which the plates in his Genera of British Insects were engraved, his family now wish to dispose of for the benefit of his children. It would be of great consequence to obtain this fine collection (which should not be broken up) for the National Museum of Edinburgh, as the British Museum already has the contemporary collection of the late Mr J. F. Stephens, and will not likely, therefore, purchase that of Mr Curtis.

Wednesday, 24th December 1862.—James M'Bain, M.D., R.N., President, in the Chair.

The Office-bearers for the Session 1862-63 were elected as follows :—

Presidents.—James M'Bain, M.D., R.N.; John Coldstream, M.D.; David Page, Esq.

Council.—William Turner, Esq., M.B.; Thomas Strethill Wright, M.D.; George Berry, Esq.; A. M'Kenzie Edwards, Esq.; Alexander Bryson, Esq.; John Anderson, M.D.; William S. Young, Esq.

Secretary.—John Alexander Smith, M.D.

Treasurer.—George Logan, Esq.

Assistant-Secretary.—James Boyd Davies, Esq.

Honorary Librarian.—Robert F. Logan, Esq.

Library Committee.—W. H. Lowe, M.D.; John Anderson, M.D. Thomas Robertson, Esq.

The following gentleman was elected an ordinary member of the Society :—

David Douglas, Esq., Publisher.

New parts of the Proceedings for the last Session, 1861-62, were laid on the table by the Secretary.

The following Donations to the Library were presented, and thanks voted to the Donors :—

1. Proceedings of the Academy of Natural Sciences of Philadelphia, August to December 1861.—From the Academy. 2. (1.) Jahrbuch der Kaiserlich—Koniglichen Geologischen Reichsanstalt, xii. Band, Nro. 2. Janner, Februar, Mars, April, 1862, Wien ; (2.) Die Fossilen Mollusken des Tertiaer—Beckens von Wien, ii. Band, Nro. 3,·4, Bivalven.—From the I. R. Geological Institute of Austria.

I. *On the Bituminous Shales of Linlithgowshire and Edinburghshire.* By Andrew Taylor, Esq.

The Geological Relations of the English and Scottish Carboniferous Systems.—The consideration of this general preliminary question is necessary in order to determine the true stratigraphical position of the shales about to be described; a point this of the greatest importance, should a comparison be instituted with bituminous substances, which have become of great commercial value in other geological systems.

Considerable misapprehension exists as to the relations oı the English and Scottish carboniferous systems. William Smith, in the course of the journeys by which he arrived at

his grand generalisation of the indication of the various ages of the strata of central England, by their imbedded fossils, demonstrated the coal-bearing strata to belong to a system perfectly distinct from the Lias and Oolite limestones and clays above, or his Greywacke system beneath. But, by a precisely similar process of reasoning, he found himself compelled to divide this system into several distinct subdivisions. Vast masses of strata were found to cover large tracts of country, which, though belonging to this system, do not possess its valuable mineral characteristics. The mountain limestone,—usually a single bed, which often attains the thickness of a thousand feet, and whose bold escarpments in the landscape include some of the most romantic mountain scenery of England,—was made the lowermost member of the series. A wild district of country immediately betwixt this and the true Coal Measures, whose chief rock was a gritty sandstone, served to mark out the subdivision of the mill-stone grit; and over this lay the really industrially valuable beds of the series, the true Coal Measures. As the nomenclature implies, this system was an artificial one, adopted mainly for economic ends; but it adds a fresh lustre to the high genius of Smith, to find that these subdivisions are also the same in a natural system, which would express the various physico-geographical changes which the strata, by our modern modes of geologic elucidation, can be made to express. The Lancashire coal-field most completely represents the various subdivisions of the English carboniferous system; and its development, as well as its relation to the Scottish system, is represented in the following table:—

Vertical Section of Carboniferous Strata.

ENGLAND—Lancashire.	Feet.	SCOTLAND—Lothians.	Feet.
1. Upper Coal Measures, .	2,000	1. (Lost by denudation ?)	
2. Middle Coal Measures, .	3,200	2. Partially denuded, .	1,000
3. Lower Coal Measures, .	2,000	3. (Supposed to be absent.)	
4. Millstone Grit, . .	3,000	4. Roslyn Sandstone Group,	1,500
5. Yoredale Rock Series. .	2,000	5. Edge-Coal Group, . .	900
6. Limestone (no sedimentary strata),	2,000	6. Lower Carboniferous Series (shales and sandstone with little limestone), . . .	3,000
Total Sedimentary Strata,	12,200	Total Sedimentary Strata,	6,400

It will be observed that while the English subdivisions in the diagram show a sequence of strata actually traced through various districts, the Scottish strata do not similarly represent such a natural classification. Care must therefore be taken, lest in an attempt after apparent uniformity of classification of these latter strata the actual physico-geographical relations exhibited in the rocks themselves be set aside. A classification denoting the succession which actually may thus be traced in the coalfields of Scotland would be of far closer approximation to the truth than the one given above. Were such an inquiry entered into, it is highly probable that it will be found that the whole Scottish coal strata are not synchronous in geological age with the English series, but are parallel only with one or two of its lowest members.

According to the diagram, the total thickness of the Lancashire strata is 14,200 feet, whilst that of the Lothians is only 6400 feet. The mountain limestone is one magnificent pile of calcareous matter in England, until it borders the confines of Yorkshire; but the equivalent series in Scotland, though containing one or two insignificant limestone beds, is in reality a succession of sandstones, coals, and shales. The Scottish analogues of the two intermediate English groups are confessedly imperfect or absent; while even the true Scottish Coal Measures but poorly represent the magnificent English members of the series in thickness or position.

Of course it will be remembered that even the smallest subdivision represents an enormous lapse of time; a lapse of time, so great, indeed, as to allow of the most extensive changes in sea and land, and a persistence in such physical revolutions utterly alien to any of our notions founded on historic time. The cycles of change in a geologic æon are not at all to be measured even by the overturning of dynasties and kingdoms in our human epoch. Consequently the Scottish carboniferous strata may represent a period of physical change very distinct from those chronicled by the English strata. The state of land and sea may have repeatedly changed,—physical conditions requisite for the deposition of peculiar minerals may have been in action and ceased at different epochs of the great Carboniferous æon.

Some recent physico-geographical investigations by Mr Hull of the Geological Survey go to prove that speculations as to such changes may have an actual foundation in fact. In a paper on the position of the arenaceous and argillaceous in contrast to the calcareous strata of the Carboniferous system of Great Britain,* it is shown on the map accompanying Mr Hull's paper, that they are developed in opposite directions; and that while the Mountain Limestone attains a development in solid mass of from 2000 to 3000 feet in the Midland district of England, it becomes thinner in Northumberland, and mixed with coal seams, while in Scotland it is attenuated to a thickness of only 70 feet. It will suggest itself, on examining the map, whether the coal strata lying above the marine limestone in Scotland, are not really on the horizon of the vast limestone masses of England? The examination of several sections appears to confirm this view. Mr Geikie has found in some parts of the Lesmahagow district, as well as on the flanks of the Cheviots, a remarkable conformity betwixt the Upper Old Red Sandstone beds and the Lower Carboniferous series.† They in fact form physically only one formation,—the distinction drawn betwixt them on geological maps being entirely arbitrary. There is a clear natural demarcation, however, betwixt these beds and the Lower Old Red Sandstones and Silurian shales, which again form only one formation. A similar uniformity of the Upper Old Red Sandstone with the Lower Carboniferous series exists in Ireland. A closer uniformity in physico-geographical relations thus exists betwixt the strata of these two countries, than with those of England.

The Scottish carboniferous strata exhibit the following succession of strata in various sections:—*First*, Immediately above the Upper Old Red Sandstone beds, and conformable with them, a series of shales and sandstones of great thickness: these are distinguished by the Burdiehouse fresh-water limestone bed, and in some places the Houston coal-seam; *secondly*, two or three beds of marine limestone intercalated

* Journal of Geological Society, vol. xviii., 1862.

† Ibid. vol. xvi., 1860.

with coal-seams; and, *thirdly*, the coal strata proper, which some hold contemporaneous with the English Coal Measures. In some places the marine limestones are 70 or 80 feet thick, but generally their thickness only averages a few feet.

In some districts the first group of strata is absent, and the marine limestone rests on the Upper Old Red Sandstone beds. The first two groups contain all the bituminous shales we are about to describe.

The Leaven Seat Shale.—One of the uppermost of the marine beds has for several years been worked at Leaven Seat, near Longridge. It is capped by a thick bed of shale, a foot and a-half of which yields, on distillation, so much paraffin as to render it of commercial value. The limestone has been traced throughout the uplands of Lanarkshire into Renfrewshire, and this bituminous shale has been found richly developed above it in various parts of its course, particularly we believe near Castlecary.

There are two interesting mineralogical characteristics of this shale. In many places its passage from the subjacent limestone may be traced. At its junction with the limestone, it has most of the petralogical characters of the latter rock; but as the bed thickens it gradually assumes a clay base. The same features are likewise distinctive of the shale below this in geological position, about to be described. The prevalence of fish scales in the shale itself, as well as the abundance of shells and corals in the limestone immediately below it, indicate that it probably owes its bituminous character to an animal origin.

Mid-Calder Shale.—The area of the series we have enumerated as the lowest member of the Scottish group, extends in segmental fashion from the Bathgate Hills to Fifeshire, and thence across the Forth at Kirkcaldy, to Gilmerton and Carlops. A well-known fresh-water limestone, extensively worked at Burdiehouse, is known to extend throughout this area. A shale capping this limestone is in some parts of Linlithgowshire so richly bituminous as to have been mined for the purposes of distillation. Chemical works, with this view, have been erected at Mid-Calder and Broxburn; and a careful observation of this shale in other quarters shows that

it retains its bituminous character throughout the county. A richly bituminous shale had lately been examined, from Carlops, near Penicuik. It occupies precisely the same geological position as that already described. It is therefore highly probable that this bituminous shale may be found throughout the whole course of the Burdiehouse limestone.

The Torbanehill Mineral.—This celebrated bituminous substance, regarded by the author as not a coal, but a variety of bituminous shale, lies stratigraphically a few fathoms above the Leaven Seat limestone, betwixt two ironstone beds. It thus lies very near the marine limestone series, and at the very base of the Lanarkshire Coal Measures. Whether it should be ranked in that series will be better determined by an examination of local geological relations than by its mere stratigraphical position.

The district in which it is situated is distinguished by the prevalence of igneous rocks; and the mineral basin itself is surrounded on two sides by trap ranges, the Bathgate and Craig Hills. The general dip of the strata is to the north-west; but an axis occurs at the point where the lower series of fresh-water strata abut upon the lower marine beds, throwing them to the south-east. Several great faults may be traced running parallel to the line of the axis. These are again met by others running at right angles to them. Thus the Torbanehill mineral basin is circumscribed by a network of faults, which serves to divide it from the underlying Balbairdie gas-coal series, and the overlying Lanarkshire Coal Measures. One boundary fault runs almost parallel with the Whitburn and Armadale road, being in fact only a few yards westwards of the road; another may be traced near the southern railway signal-post of the Bathgate Station, running at right angles to the Wilsontown line of railway; a third runs from a point near Woodend village on the Craig Hills, a little beyond the lower part of Armadale village, past Middlerig and Hard Hill into the Bathgate Hills; while a synchronous fault probably appears near Wester and Easter Whitburn. The mineral is always found thinning out near those lines of

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fault. If the Craig and Shotts Hills be proved to be of contemporaneous age with the Bathgate Hills, the proof will be almost conclusive that the mineral is simply a local deposit.

The contemporaneous nature of the traps of the Bathgate Hills is very clearly made out from the local section. If we begin our examination of the hills at the Clinking Stane, a mile and a half above Bathgate, we shall find to the eastwards, at a south-east dip, the fresh-water Burdiehouse limestone strata much intercalated with igneous rocks, which, along with the faults already alluded to, help to throw the strata into a number of small basins. Proceeding towards Bathgate, the succession, until we come to the outcrop of the Balbairdie gas-coal and ironstone, is a series of marine limestones intercalated with beds of contemporaneous greenstones. Beyond the outcrop of the Balbairdie gas-coal, we soon come on the fault bounding the outcrop of the Torbanehill mineral.

Perhaps no local section in Scotland exhibits so many petralogical characteristics demonstrating the contemporaneity of the igneous and aqueous rocks. A little beyond the site of the ancient crater, at the Clinking Stane, we traverse the outcrop of two limestone beds, which clearly testify three marked changes in the physical features of the land. *First*, The Kirkton limestone, with its leafy laminæ and curiously baked beds of cherty porcelain, its interstratified ash, and over-capping basalt, indicate a close proximity to volcanic activity. Its fluvio-marine fossils indicate it to be the stage when the great river which formed the freshwater strata of the east side of the axis ceased. A few hundred yards westward we meet the outcrop of the Peter's Hill bed, and its decidedly marine fossils clearly indicate how soon the land had given place to a sea deep enough even for building corals to begin their long labours. After the great limestone belt of the hills had been thus formed, a complete physico-geographical change again ensued, in which dry land had the predominance. The Balbairdie gas-coal series were now deposited; and the sheets of bedded trap with which they are intercalated must have been erupted from the vol-

cano. The Leaven Seat limestone is found immediately above these beds; and as it abounds in marine fossils, another change of land and sea must have ensued at its formation. The whole strata were once more elevated by the great fault forming the boundary of the Torbanehill mineral basin. And if the Craigs and Shotts Hills were of contemporaneous age with the Bathgate range, we may easily trace the shores of the lake in which this very peculiar mineral substance was formed; and we will likewise be led to the conclusion that it was separated by physical barriers from the upper Coal Measures of the Clyde Basin. The contemporaneous character of the traps found to the eastward of the range, both in Edinburgh and Linlithgowshire, has been ably proved by the labours of Mr Geikie and others.

It is surely in nowise very hypothetical to assume, that some relation exists betwixt the intense diffusion of trap, and the extensive prevalence of bitumen in the district. Bitumen oozes from the trap rocks of Winchburgh; it occurs in circular blots in the Binny sandstone, and permeates the overlying limestone shales of Mid-Calder and Broxburn. Now, we know of two methods by which this substance is eliminated in nature. *First*, It appears when we confine organic matter in a close vessel, and when in the absence of the oxygen of the atmosphere, the carbon and hydrogen unite to form its various compounds. *Secondly*, It is ejected as an oily fluid from mud volcanos. Mr G. Walls, in an able paper on the geology of Trinidad, remarks:—"The phenomena of salses, or mud volcanos, consisting of the solution of inflammable gas, accompanied by the discharge of a muddy fluid and asphaltic oil, is perhaps closely related to the activity first described, as carburetted hydrogen may be disengaged in the direct formation of asphalt. Several of them occur in Trinidad, also in the newer Parian formation."* I am inclined to ascribe the bitumen of the Balbairdie household and gas coals,—and in bituminous coals generally,—to the first method of forming bitumen. Again, I think that the structural character of the district fairly justifies our ascrib-

* Geological Journal, vol. xvi., 1860.

ing the formation of the Torbanehill mineral and the shales described, as well as the isolated bitumen so frequently met with in various rocks of the district, to the second method of injection. It was admitted by the late Dr Fleming that the stratified traps we have described do not necessarily demand intense heat for their formation, but may be best accounted for by ejection from a mud volcano, and subsequent assortment by water. A careful examination of their junction with the stratified rocks will convince observers that this is the most philosophical view of their formation. Surrounded by such a mass of organic rock, the ejection of bitumen from the ancient salses, which have left such abundant proofs of intense activity, is a by no means extravagant assumption.

I would, then, draw the following conclusions as to the Torbanehill mineral bed:—

1. The Scottish Carboniferous system is probably of much earlier age than the true English Coal Measures, being physically more united with the Upper Old Red Sandstone series. Further research may probably yet prove the Scottish Carboniferous and Upper Old Red series of rocks to correspond with the English Mountain Limestone series in reality, and form one formation. 2. The strata east and west of Bathgate are the underlying beds of the Scottish series, and must be taken as covering a great lapse of time prior to the deposition of the upper fresh-water coal formation of Lanarkshire. 3. The petralogical peculiarities of the strata around Torbanehill are such as to justify us in assigning a distinct method of formation to a mineral which neither physically, chemically, nor microscopically possesses the characteristics of a true coal. 4. The Torbanehill mineral is diffused over a limited area; a distinct stratigraphical position cannot therefore be assigned to it in any general synopsis of the Scottish Coal Measures.

An interesting discussion followed, in which the President Dr M'Bain, Professor J. Y. Simpson, Mr A. Bryson, Dr Stevenson Macadam, Dr Murray Thomson, and others, took part.

II. *Ornithological Notes.* (1.) Pernis apivorus (*Flem.*), *the Honey Buzzard.* (2.) Tetrao urogallus (*Lin.*), *the Capercailzie* (*female in male plumage*). By JOHN ALEX. SMITH, M.D.

(1.) *Pernis apivorus*, the Honey Buzzard.

A fine specimen of an adult female was shot by Mr Gavin Hill at Dalmahoy, near Ratho, on the 13th June 1862. The bird was comparatively tame, flying from branch to branch of the tree. Length from bill to point of tail 24½ inches. The extended wings measured, from point to point, 4 feet. The lores covered with the small scale-like imbricated feathers. The stomach was filled with the semi-digested remains apparently of wasps and their larvæ, and the elytra of beetles; the eggs in the ovary were well developed. I have previously exhibited to the Society two specimens of this bird,* it is however rare, in Scotland; and from the season when it has been killed, as well as from its insect food, is believed to be merely an occasional summer visitor.

(2.) *Tetrao urogallus*, the Wood Grouse or Capercailzie.

The bird exhibited was an example of a curious change of plumage which occasionally takes place in birds,—*a female assuming the plumage of the male.* This capercailzie is a female of the ordinary size, but the general dark character of its plumage is that of the adult male.

Length nearly 26 inches; of wing from flexure, 12 inches; fourth primary a little longer than the third, and the longest in the wing. Bill, light horn colour, especially at tip. Plumage of throat glossy black; head and neck, upper and lower parts of back, dark grey and black mottled; wings, wing coverts, and middle of back, dark reddish-brown mottled with black, and slightly also with grey; the points of some of the scapulars and tertials slightly tipped with white; the primaries dark brown, mottled on outer webs with grey. Tail rounded, dark grey nearly black, the base of the feathers being slightly mottled on their outer webs with greyish-brown; tail coverts mottled with grey and brown, and outer feathers tipped with white. Lower part

* See Proc. vol i. p. 240.

of neck and breast with broad band of dark glossy green, showing reddish purple reflections when looked at laterally, which is also to be observed in the male capercailzie (this reddish purple colour of breast seems entirely to take the place of the green, in the hybrid between this bird and the blackcock,—the *Tetrao medius* as it has been named). At lower part of breast, the green colour passes into blackish brown, mottled slightly with grey at the sides; below, and abdomen, white or nearly so, with numerous spots of black, the dark feathers being broadly tipped with white; lower tail coverts black, tipped with white; thighs white, legs and feet dark grey, the toes being dark brown, with the claws nearly black. The colours of the plumage, however, are not quite so brilliant as in the male.

The bird was shot on the 2d November, near Dunkeld, on the property of Hugh Bruce, Esq. Mr Sanderson, bird-stuffer, George Street, has sent along with it adult specimens of the male and female for comparison, and its resemblance to the male is very striking. Mr James Keddie, Mr Sanderson's assistant, called my attention to the finer texture of the accessory plumes of the feathers, in all female birds showing the plumage of the male. Yarrell described this change to the male plumage as having been observed in various species of birds, but apparently had seen no instance in the capercailzie; he says, M. Nilsson, in his "Illustrations of the Fauna of Scandinavia," has figured "a female of the wood-grouse in the plumage of the male, which he truly calls a barren female," and he copies the drawing in his "British Birds." The bird now exhibited closely resembles that figured by Yarrell, with the exception that its tertiaries and scapulars seem to be more tipped with white, and, so far, slightly resembles the plumage of the adult female.

In 1857 I exhibited to the Society various specimens of the pheasant, showing this curious assumption of the male plumage.* The general opinion is, that a change of this kind occurs along with an atrophied or changed state of the ovaries, the result of age it may be, or of disease. In this

* See Proc., vol. ii. p. 58.

bird the ovary showed at the lower part, eggs the size of rapeseed, but a considerable part of the organ was darker in colour than usual, and harder in texture, apparently from disease.

I am not aware of any instance of the female capercailzie assuming the plumage of the male having previously been recorded as occurring in Britain.

Wednesday, January 28, 1863.—DAVID PAGE, Esq., President, in the Chair.

Alexander Edmonston, Esq., publisher, and John Sadler, Esq., were elected members of the Society.

The following donations to the library were laid on the table, and thanks voted to the donors:—

1. Transactions of the Zoological Society of London. Vol. IV., Part 7, 1861. 2. Proceedings of the Zoological Society of London, 1861, Part 2, March, June.—From the Society. 3. The Canadian Naturalist and Geologist, and Proceedings of the Natural History Society of Montreal. Vol. VII., Nos. 2, 3, 4, April, June, August, 1862.—From the Society. 4. (1.) Memorias de la Real Academia de Ciencias de Madrid. Tomo III., Ciencias Fisicas, 1859. Tomo IV. Ciencias Naturales, 1859. Tomo V., Ciencias Naturales, 1861. (2.) Resumen de las Actas de la Real Academia Ciencias de Madrid, 1853, 1854, 1855, 1856, 1857, 1858, 1859.—From the Royal Academy of Sciences of Madrid.

The following Communications were read:—

I. *Remarks on Torn-off Digits in Man, with Reference to Analogous Injuries in the Lower Animals.* By A. M'K. EDWARDS, Esq., F.R.C.S.E. (Specimens were exhibited.)

The subject I am about to bring before you, though perhaps an unusual one for the Royal Physical Society, is, I think, an interesting one. Perhaps those members acquainted with the accidents which happen to wild animals may give us some information which may throw light on that very curious class of injuries,—the tearing away of limbs or portions of limbs. I intend confining myself to the tearing away of digits (and would first of all lay before the Society this specimen, No. 1).

This subject was brought before the notice of the French Academy so long ago as 1753, when a large number of cases were published in the Memoirs of that society.

The specimen I now show is the last phalanx of the right thumb of a boy. He lost it under the following circumstances:—Having tied one end of a string round his thumb, and the other to the wheel of a turning-lathe, a companion set the treadle in motion, the object of ambition being to check the wheel when it was revolving rapidly. He suddenly found that the string was flying round independent of his thumb, and on trying to fasten it again, behold it had disappeared. On a careful search it was found lying at some distance in a distant part of the shop. He complained of no annoyance in the shape of pain.

On examining the detached portion, I found that the first phalanx was completely separated, the skin having given way sooner—or, to speak more correctly, more skin being left behind than in front. The tendon of the long flexor of the thumb was separated in its whole length, and had a fringe of muscular fibres hanging to it. The digital nerves had been drawn out for about one inch and a half. The blood-vessels, naturally very minute, did not bleed. Along the track through which the tendon, with part of its fleshy belly, had been thus violently rent, there was scarcely any tenderness, and except when dressing the stump, the lad complained of no pain, and soon got well. A very similar case is recorded by Mr Recolin, of a man, at seventy-two, who endeavoured to stop some runaway horses, and to get a firmer grasp of the reins, twisted one of them round his right thumb,—the first phalanx separated from the second, the skin being cut as with a knife at the edge of the joint; the extensor tendons had given way, and hung round it as a fringe; the tendon of the long flexor was separated in the whole of its extent, with many portions of its fleshy fibres.

The next case I would show the Society is also a portion of a thumb, and also the last phalanx. It was torn from a lad who imprudently placed his hand in too great proximity to some machinery; the rope, which is still attached, caught the tip of the thumb, and cut through the soft parts to the bone. Then everything yielded,—skin, ligaments, vessels,

nerves, and tendons, all but two; the extensor of the last phalanx and the long flexor, these came away in their whole length, carrying with them some of their fleshy fibres. This patient recovered with scarcely any suffering.

The digits most prone to such mishaps are undoubtedly the thumb and little finger; this may be partly accounted for by their being flanking fingers, and so somewhat more exposed to injury. I can only find one case recorded where one of the central fingers suffered. A woman was standing on a stool endeavouring to hang up a joint of meat. The stool turned over, and the hook caught her ring finger near its root; the weight of her body caused the finger to separate, with rupture of all the soft parts, except the tendon of the deep flexor, which came away with fleshy fibres attached.

But there are numberless cases on record of the flanking fingers, and especially the last phalanx, separating from apparently trivial causes. A friend of my own once descended somewhat hurriedly from the box-seat of an omnibus. He was about to turn and walk away, when a gentleman who had been sitting beside him said politely, "This is *yours*, sir, I believe," and handed him down the last joint of his left little finger, with its extensor tendon attached. Some years ago, a gentleman walking down Elder Street when the pavement was slippery, as a precautionary measure held his hand over the railing in readiness for a slip; he slipped and fell, his signet ring was caught by one of the spokes of the railing, and tore off his little finger.

The peculiarities of such are:—

1. The small amount of force necessary—tendon, belonging to short masses of muscle, or muscular bellies common to several tendons, give way either at the seat of injury or where they commingle with the muscular fibre.

2. Long tendons running in separate sheaths, playing freely in grooves of their own, do not give way, but the fleshy fibres do; and we can, as was shown long ago by M. Morand, imitate this on the dead body.

3. They are seldom accompanied by much pain, at all events at first, as shown by the instances I have mentioned;

even large portions of limbs may be torn off without either the suffering or shock we would expect to meet with.

M. Benomont mentions the case of a child of nine who clambered up behind a coach and six. One of his legs got between the spokes of the wheel, and before the coachman could stop his lumbering vehicle, the limb was torn off at the knee. The child was taken to a shop, where he shouted so loudly for his leg that they were obliged to bring it and show him it; having seen it, he entreated them to fasten it on again, so that his mother should know nothing about it. Benomont promised to do so, and the lad was at once tranquillised and happy.

I should like to know whether, in those cases where animals tear themselves out of traps, the tendons separate or the muscular fibres, and if they lacerate themselves intentionally, or whether it is an accidental circumstance occurring in the struggles of a paroxysm of terror, and do they suffer as little as the human species seem to do from these injuries.

IV. *Some Remarks on Mineralogical Classification.* By ANDREW TAYLOR, Esq.

Analogy is not resemblance. Hence classifications based merely on analogy, however apparently symmetrical, in reality retard the progress of science. Modern chemical research appears to indicate faults of this nature in our present systems of mineralogical classification.

We have too exclusively given over minerals to the domain of the crystallographer and the chemist. Our mineralogical treatises are thus very much a series of mathematical and chemical formulæ. We have defined a mineral to be a substance possessing a definite chemical composition and geometric form. Does this definition really meet the circumstances of nature? Recent chemical analyses, and the application of the microscope to the problems of physical geology, by Bryson, Sorby, and others, appear to show that this definition must be enlarged. If minerals shall ever serve to indicate the character of the great physical and

chemical perturbations that have eliminated our mountain masses—as fossils have told the story of past life on the globe,—our nomenclature must be enlarged to suit their new application. Without attempting to show in what way this revolution might be effected, I shall merely indicate how recent researches are exhibiting the defects of the present system.

Certain recent investigations of Professor J. P. Cooke of America,* on two new compounds of zinc and antimony, go to show that the harmony of chemical composition and form, as laid down in mineralogical books, is subject to deviations, which are apparently undefined laws. The two compounds experimented on are named respectively *stibiobizincyle* and *stibiotrizincyle;* and their chemical symbols are Sb,Zn^2, and Sb,Zn^3. The two crystalline forms which they assumed, were found to be constant under very wide variations of the per-centage of the chemical constituents of the crystals. Crystallizations were made, or attempted, of alloys differing in composition by one-half to 5 per cent., according to circumstances; from the alloy containing 95 per cent. of zinc to that containing 95 per cent. of antimony; but only the two crystalline forms were obtained.

If, thus, two beautifully crystallised products differing so very widely that any single analysis might lead to an entirely erroneous conclusion as to the general formula of the substance, the question arises, may not such variations in composition be quite compatible with the persistency of the crystalline forms found in nature? From a variety of examples, Professor Cooke shows that this actually prevails. As a consequence, the general chemical formulæ of some of the best known mineral species, such as mica and tourmaline, are still uncertain. The results of these investigations must greatly modify our notion of a mineral species. The idea of this has hitherto been,—first, a definite crystalline form; second, a constant general formula; and any important variation in either of these characters has been regarded as equivalent to a change of species.

* Silliman's American Journal of Science, vol. lxxix. 1860.

And if our ideas of a mineral species be thus overturned, so will the consequent classification into orders and genera. In the re-arrangement of our mineral orders, it may be found expedient to include their derivative rocks. Thus, observers may afterwards find that peculiar minerals characterise certain classes of volcanic rocks, whilst the metamorphic rocks are the special habitat of others, and the sedimentary or organic of yet different varieties. This would thus involve, that our treatises on mineralogy contain likewise much more of petrology than they ever have done.

The examination of what is given in our mineralogical treatises as the seventh order, the Inflammables, will show how artificial our present classification is. In it we have sulphur, coal, the resins, the inflammable salts, minerals no doubt possessing one physical character in common, but differing wide as the poles asunder in their other characters. Nor are the subdivisions of the order more satisfactory, as is well known from the repeated recurrence in our legal courts of the question, "What is coal?" Chemistry has been mainly relied on in considering this query. But a little study of the order will convince us that the foundations on which we build our individual discriminations of the various minerals must be physical and not chemical. A close chemical analogy subsists betwixt minerals of the order otherwise manifestly of very different properties. Thus, certain varieties of bitumen and cannel coal are nearly identical in chemical composition. Again, peat, coal, the bitumens, the ambers, are all under the same chemical category. But reasoning based on such an analogy may lead us into serious practical mistakes. Thus it has been generally assumed that bitumen and coal were of vegetable origin. Now, it has been indisputably proved that the petroleum of Canada is of animal origin—the animal remains of the coral builders of the Silurian and Old Red Sandstone reefs of the American continent yielding the material whence it is derived. Again, many shales must have obtained their bituminous character from animal remains, as is shown both by their imbedded fossils and their juxtaposition with limestone beds, richly fossiliferous. Some shale beds are en-

tirely composed of trilobites or small fossil shells, while others, which have been used for the distillation of paraffin oil, lie immediately above richly organic limestone beds. The classification which would make shale and coal imperceptibly merge into one another, mainly because of a chemical similarity, is in my opinion clearly erroneous.

Might not the organised structure visible in certain rocks be employed as a distinctive feature in arranging this order? We would have little difficulty in distinguishing two great classes of rocks and minerals: *first*, those indubitably showing by the microscope their organic texture; and, *secondly*, those which, while they do not exhibit microscopic structure, yet clearly indicate, by their chemical composition, a secondary organic derivation. We might thus create one great order, and as important a sub-order. The order would include the limestones and the various varieties of coal, including peat, anthracite, cannel coal. The sub-order would comprise the bitumens, ambers, &c.; in short, with the exception of sulphur, all the genera included in the seventh order. The species and varieties of bitumens and resins would thus be more easily capable of specific subdivision. The animal or vegetable origin of the bitumen family might thus be left open, and shales would not be confounded with coal. The bringing together of two such apparently different bodies as limestone and coal is merely a popular objection to our general proposal. By following the path of inductive science, light might be obtained on many dark questions in petrology. As a sample, the microscopist now detects bituminous globules in rock crystal; let him apply his art to calc-spar and the conjoined families, and what curious resemblances to minerals, from which they are apparently very different, may he not discover?

We might, too, relegate into a distinct class the Torbanehill mineral, the Albertite of Pictou, and the mineral of St John's, N. B.,—bituminous substances the true nature of which has been the cause of so much discussion amongst scientific men. In the opinion of many most competent observers, these minerals exhibit no microscopic structure similar to coal; while several able chemists affirm that their

chemical composition differs from both coal and bitumen; and they are unique in affording commercially valuable substances, whence the industrialist may profitably extract paraffin oil. Such minerals, and any similar substances which may yet be discovered, deserve to be more clearly disjoined than they have been from the ordinary mass of cannel coals or bitumens.

III. (1.) *Notes on a Young Otter* (Lutra —— ?), *&c. recently sent from Old Calabar, Africa.* By JOHN ALEX. SMITH, M.D.

This small specimen of an otter, preserved in spirits, and now exhibited, was sent to me a few days ago by Dr Hewan, Old Calabar, through his friend, Andrew Elliot, Esq., publisher here. I need not remind the Society how much all naturalists, and our Society in particular, have been indebted to the gentlemen of this United Presbyterian Mission for various additions made by them to the different divisions of the animal and vegetable kingdoms.

Dr Hewan informs me that "this species of otter is named by the natives of Old Calabar the *Jyūng* (the *ū* being sounded like *ou* in you), and with age it grows to the size of a spaniel or poodle dog. It inhabits both marshy and dry land, and lives on fish—small kinds caught on the banks of the river at low water; also on shell-fish, such as craw-fish, &c."

This young animal is of a light ash or pale mouse colour, and of a darker mouse colour on the upper part of head, and across the muzzle in front of the eyes; the muzzle and sides of the head, as well as the chin and throat, and the back part of the neck, being a light fawn colour, almost white. There is also a darker spot of brown on the outside of the fore legs,—the fore feet, as well as the hinder feet, being lighter in colour. The under surface of the animal, like the upper, is of a pale mouse colour; the tail is of the same colour, rather short, flattened horizontally, and tapers to a point. The head is broad and rounded, and the whiskers of muzzle and cheeks are thick and long. The ears are short and round, and darker in colour on their inner surface.

It measures about 17 inches in length from the muzzle

to the point of the tail. The head is about 3½ inches in length; from back part of head to the root of the tail, 8 inches; and from root to point of tail 5½ inches. The muzzle measures 3 inches across the face, at the back part of mouth and in front of the eyes. The eyes are distant three-quarters of an inch from the back part of nostrils; and from the same part of nostril to front of ear it measures 2 inches. The opening of the eyelid is little more than a quarter of an inch in length. The short and rounded ears measure nearly half an inch from above downwards, and also from before backwards—the top of the ear being on a line with, or only very slightly below, the level of the eyes.

The only teeth yet developed in the jaws are six incissors and two canines in the upper jaw, and apparently four small incissors and two canines in the lower. Beyond the canines of the upper jaw, there is a large projection of the gum on each side, indicating a prominent molar tooth; and a corresponding but much less prominent projection also occurs on each side of the lower jaw. The tongue is comparatively smooth on the upper surface, but is covered with elongated papillæ on the outer and under part of its edge.

The feet are large and rounded, the toes being webbed nearly to the beginning of the distal phalanges; the third toe (counting from the inside of foot) is the longest in each foot, and the fourth is nearly equal in length; the second toe being slightly longer than the fifth or outer toe. All the toes of both feet have small but distinct sharp-pointed hooked nails or claws. The feet are thinly covered with short light-coloured hair, and their under surface is free from hair.

Our highly valued member and friend, Mr Andrew Murray, now resident in London, some time ago got a skull of an adult otter sent him from Old Calabar by Mr Thomson; and in his notes of the various animals found at Old Calabar, published in the Proceedings of this Society for 1860,* he states its dentition differs from that of the common otter, *Lutra vulgaris*, in having one fewer premolar in the upper jaw. Mr Murray had submitted the skull to "Professor Owen, who considered it nondescript, and that it approaches

* Proceedings Royal Physical Society, vol. ii. p. 157.

Enhydra of Fleming (Philosophy of Zoology), in having the first premolar suppressed above, but that the latter has also the first premolar suppressed below. It has, however, six incissors in the under jaw, while the sea otter, *Enhydra*, has only four in the adult state." "It would appear to form an intermediate link between the true otter and the sea otter." Mr Murray accordingly proposed the generic name of *Anahyster* (belonging to an estuary). *Anahyster* (Nov. genus of otters) *Calabaricus*, Murr.

Whether or not this small specimen is the young of the animal described by Mr Murray, I cannot of course determine. Unfortunately its imperfect dentition renders it impossible to decide; and we are also at a loss as to whether the four incissors of the under jaw are the permanent number, or, from its youth, are simply incomplete. The general characters of this young animal, in the feet and other respects, seem to correspond with those of the restricted genus *Lutra* of authors, more than with the genus *Enhydra*. The arrangement of the colours of its skin appears to be peculiar, but may possibly be simply dependent on its youth. It apparently does not resemble its nailless neighbour, the *Aonyx Delalandi* of Lesson, which, according to him, also lives on fish and crustaceans, from the salt lakes of the sea-coasts near the Cape. I would be inclined, therefore, to use, provisionally, Mr Murray's name of *Anahyster Calabaricus*, or simply that of *Lutra Calabarica*. Adult specimens of skins and crania, will, I trust, by and by be sent from Old Calabar, to enable us to settle the question of the generic or specific resemblance or difference of these otters. Its anatomical details I have not as yet been able to examine.

EPIZOA *from the Otter.*—Two small specimens of *epizoa*, which I exhibit, were detected on the skin of this young otter; I have not, however, been able at present to determine their species.

CHRYSALIS *of a Moth from Old Calabar.*—I also exhibit another contribution from Old Calabar, a large black-coloured *Chrysalis*, apparently of a species of moth. It is oval in form, measures 2¼ inches in length, and 2¾ inches in circumference at the thickest part, about the middle of its length.

(2.) *Note on the Red Bill and Legs of the Young of the* Fregilus graculus, *the Chough or Red-legged Crow.* By John Alex. Smith, M.D.

Some time ago I read a communication from the Rev. Thomas B. Bell of Leswalt, entitled, " Notes from the neighbourhood of Stranraer,"* in which he gave details of the habits of this locally distributed bird, which occurs rather abundantly in his neighbourhood. The bird breeds there in considerable numbers in the cliffs of the sea coast; and at my request Mr Bell kindly undertook to settle the apparently doubtful question as to the colour of the beak and legs of the young birds, whether they were red or black—a matter of fact which appeared to be still undecided among ornithologists.

Macgillivray, in his " British Birds," states that—" The young are said to have their first plumage black, but without the gloss and purple tints of the adult birds. The bill and feet are stated by M. Temminck to be at first black, but Montagu affirms that they are red from the commencement. I have not seen a bird in its first feathers, and it does not appear that any recent British writer has had an opportunity of deciding the question."

Yarrell mentions that the bird of the first year has the legs orange red, but says nothing about the colour of the bill.

Mr Bell informs me, as the result of his examination—what indeed might have been expected—that both the bill and feet are red in the young birds in the nest, the colour not being perhaps quite so bright as it afterwards becomes.

Through his kindness I exhibit a specimen of the bird, taken at Larbrax, in the parish of Leswalt, Wigtonshire.

Thursday, February 26, 1863.—James M'Bain, M.D., R.N., President, in the Chair.

Alfred Brett, Esq., Lecturer on Materia Medica, New Veterinary College, Edinburgh, was elected a member of the Society.

The following donations to the library were laid on the table, and thanks voted to the Donors :—

1. Annals of the Botanical Society of Canada, Vol. I., Part 3, 1862.—

* Proceedings, vol. ii. p. 143.

From the Society. 2. (1.) Memoirs of the Literary and Philosophical Society of Manchester, Third Series, Vol. I., 1862 ; (2.) Proceedings of the Literary and Philosophical Society of Manchester. Vol. II., 1860–61 and 1861–62 ; (3.) Rules of the Literary and Philosophical Society of Manchester. 1861.—From the Society. 3. Proceedings of the Literary and Philosophical Society of Liverpool during the Fifty-first Session, 1861–62. No. 16, 1862.—From the Society.

The Communications read were as follow :—

I. *On the Fossils of the Boulder-clay of Caithness, N.B.* By C. W. Peach, Esq., Wick.

Notwithstanding all that has been written on the boulder-clay, little is known about the fossils belonging to that formation in Caithness. I therefore venture to lay before you a paper on the subject.

This clay may be traced all over Caithness ; in some places it is very deep, especially in estuaries, and on the sides of our rivers and burns. Some sections show a depth of 60 or 80 feet. In some places it is from low water mark to 200 feet and upwards above the level of the sea. It differs greatly even in the same locality, for in spots shells are abundant with very few stones, and the clay not very hard. At a short distance from this, stones are abundant, shells rare, and the clay so compact, that it cannot be blasted by gunpowder, nor will it yield to the pickaxe beyond the small piece into which it is driven. Occasionally it contains very large blocks of stones, mingled with smaller ones, not in regular layers. The stones are of all kinds, granite, porphyry, gneiss, quartz, &c., Silurian, Old Red Sandstone, chalk-flints, oolite, lias, limestone, &c. &c. I found at Wick one piece from the *Crag*, known to be so by a characteristic shell embedded in it. Many of these derived rocks contain fossils, whilst ammonites, belemnites, fossil wood, &c. &c., are also loose in the clay. Almost all the stones, and even the fossils, are more or less worn, polished, and striated.

The rocks on which the clay rests are also polished and grooved, many of these grooves are very deep and coarse, others very fine, occasionally the surface is very smooth, when on quartz rock, often brightly polished. All the grooves that I have met with on rocks below the clay in

Caithness, run north and south, with deviations to the east and west. I have found them almost all over the county.

Beds of sand occur in some localities over the clay, and nests of sand are occasionally in it. Cracks, varying from an inch to a foot across, run down the clay to great depths, some vertically, others diagonally, and from these run, horizontally, smaller ones; all these are filled with sand. The sand contained in them was evidently poured in from above, first trickling down the sides mixed with tenacious matter, and which has consolidated there, the centre of the cracks being filled with loose sand. The shells in the sand are of the same kind as those in the clay, but so friable, that on attempting to remove them, they fall in pieces—thus showing that sand is a bad preservative of organisms embedded in it.

In many cases where thick beds of sand occur, clay again overlies it, and above all, beds of stones of all kinds and sizes, which no doubt were left by the after washings to which the clay had been subjected, the clay being carried away to other localities, and in all probability forms the brick-clay, which is said to be younger than the boulder-clay.

At Pulteney Town, near the harbour, a large block of granite, many tons in weight, rests on the Boulder-clay, 66 feet above the level of the sea. All over the county large boulders are met with. The march of improvement is destroying them fast. The largest I know is at Reiss, Wick, a conglomerate block; its cyclopean size makes it a conspicuous object in the flat field near the farm-house of Kilmster. All the clays of Caithness, or nearly so, might be made into bricks, tiles, &c.; it, however, would be rather expensive to take out the stones. This could be done by washing when preparing the clay for use. A similar clay is so treated at Peterhead, Aberdeenshire; the wares made from it are highly prized, and it has been worked *profitably* for years. In this clay-work I have found similar shells to those of Caithness, but much more comminuted, and in less abundance. It is also very full of stones.

Some of the Caithness shells are almost perfect, especially the smaller ones; others, again, for instance the *Astartes*,

are still covered with their epidermis. In no case have I found two valves united. Several of the shells are perforated by the *whelk* and the sponge *Cliona*. Some of the zoophytes, *Polyzoa*, are attached to broken shells; other markings are also seen on them like those on our present living shells. Many of the shell fragments have their broken edges rounded; others, again, are as sharp as if only just broken. This latter circumstance, I know, causes surprise, and often difficulty to many. All this will vanish if those doubting would collect shells on the present sea-shores; they will find that rounded and sharp fragments occur together, agreeing in every respect with those found in the Boulder-clay.

Most of the organisms of the Boulder-clay are still to be found alive on our own shores, as may be seen by the accompanying lists,—two only of the shells, viz., *Astarte arctica* and *Tellina proxima*, being *Scandinavian*; one alone, viz., *Trophon scalariforme*, being ARCTIC. The mode of transport of the materials of the Boulder-clay, in all probability, has been ice, either by glaciers or icebergs. As I wish only to introduce the organisms of its own age, I must leave this part of the subject to others.

I think it right to state that the whole of the shells have been examined and named for me by J. Gwyn Jeffreys, Esq., the sponge *Geodia* by Dr Bowerbank, both excellent authorities; therefore the list may be safely accepted as correct. For the remainder I am answerable.

The greater part of these organisms have been collected by myself, assisted by my sons. All the species got by them I have also found; and in no case have I admitted into the list any specimen found in a *doubtful position*, always keeping in view the human skull and rybat mentioned by the late lamented Hugh Miller. Had I been inclined to do so, I might have noticed the skull of an *Arvicola* from the Wick cliffs, found in a much less doubtful position than the human one. I have taken only those *dug out of the solid clay*. The whole of the specimens are in my possession, and I shall be happy to show them to any one working in this field of research.

List of Fossils.

UNIVALVES.
Trophon scalariformis
Buccinum undatum
Nassa incrassata
Purpura lapillus
Mangelia Trevelliana
turricula
Natica nitida
sordida
helicoides
Aporrhais pes-pelicani
Turritella communis
Trochus Zizyphinus
Patella vulgata
Dentalium entalis
abyssorum (N.S. Sars)

BIVALVES.
Pecten maximus
opercularis
Leda caudata
Cardium echinatum
edule
Norvegicum
Cyprina Islandica
Astarte arctica
compressa
elliptica
Astarte sulcata
Artemis lincta
Tellina proxima
solidula
Mya truncata var. Uddevallensis
Panopea Norvegica
Saxicava rugosa, var.

BALANIDÆ.
Balanus Scoticus (porcatus)

ANNELIDA.
Serpula vermicularis

POLYZOA.
Hippothoa catenularia
Membranipora
Lepralia Peachii
simplex

SPONGES.
Geodia
Cliona celata

ALGÆ.
Nullipora (Melobesia) polymorpha

Recapitulation of Species.

15 Univalves, 17 Bivalves. 1 Balanus; 1 Annelide; 4 Polyzoa; 2 Sponges; 1 Coral; 1 Alga.—Total, 42 species.

Of the 32 Shells, 29 *are British*; 2 *Scandinavian*; 1 *Arctic.* All the other objects are British.

Several members stated that, after long-continued examination, they had been quite unable to discover any organisms in the *true* BOULDER-CLAY.

They were all well aware of the very correct character of Mr Peach's explorations, still they could have wished he had been a little more explicit in his details of the clay-beds, and the exact localities in which the various organisms described by him were found.

The occurrence of what had been named the 'Brick-clay Beds' overlying the true boulder clay were well known; and in these brick-clays various fossil remains had been found; their relation to the boulder-clay being probably, first the beds containing boreal shells, and next those with shells belonging to species still living in the neighbouring seas. To this last and latest class they were inclined to consider that the clay-beds with their recent fossils described by Mr Peach, most probably will be found to belong.

II. *Observations on British Zoophytes.* By T. STRETHILL WRIGHT, M.D. (Plate I.)

(1.) *On a Supplementary Canal System in* Stomobrachium octocostatum.

Stomobrachium octocostatum (Forbes) is occasionally found in the Firth of Forth, in the neighbourhood of Queensferry and Granton. All the specimens of the animal which I have taken have been females, and as Stomobrachium is one of those medusæ which feed and thrive well in captivity, I have repeatedly endeavoured to obtain young zoophytes from them in the hydroid stage of their existence, but hitherto without success, as the development of the ova in the ovarian bands invariably became arrested soon after the animals were removed from the sea. I have little doubt, however, that the hydroid phase of Stomobrachium will eventually be obtained, and that it will prove to be a Tubularian polyp allied to *Atractylis* or *Clavula,* inasmuch as its medusoid form is destitute of otolithic sacs, organs which are always absent in the medusoids of Tubularian zoophytes.

Several years ago I accidentally noticed a single minute yellowish polyp resembling Clavula, and having three rows of filiform tentacles, attached to a stone in a large tank, in which a specimen of Stomobrachium was confined with other zoophytes, but I was unable to trace any connection between the polyp and the medusa, as the planuloid larvæ of the latter were not ripe for extrusion, and never became so, although the medusa lived for many weeks.*

* In observing the reproduction of a naked-eyed Medusa, the greatest care must be taken that the water used in the experiment is perfectly free from the presence of planuloid larvæ of other forms, which are frequently contained

PLATE I.

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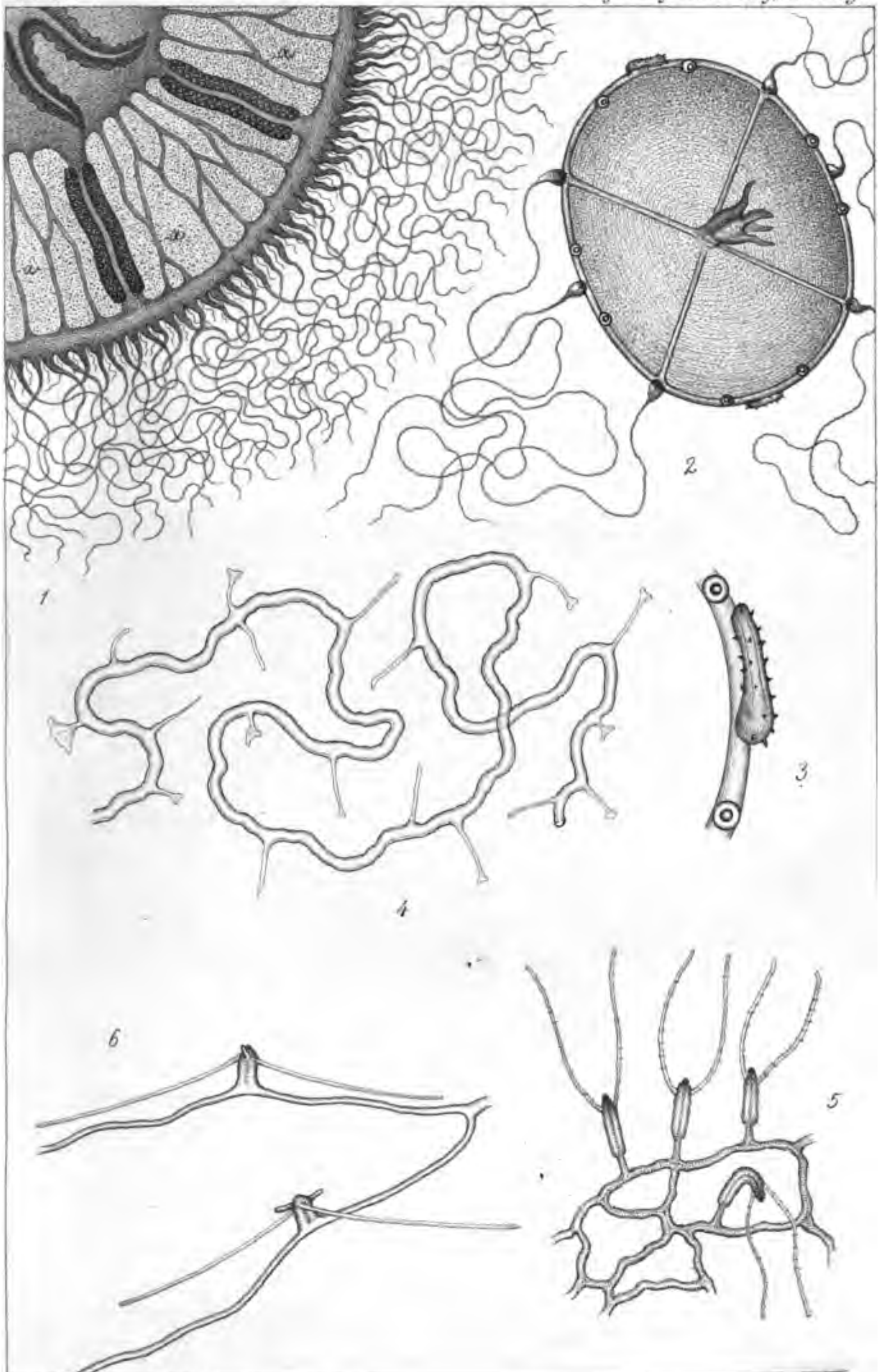


T. Strethill Wright, del. — on stone by F. Keith.

On examining a specimen of Stomobrachium last summer, which had been recently fed on the white part of an oyster, I noticed (fig. 1 *a a a*) a retiform system of fine canals, which permeated the muscular web of the sub-umbrella, and was altogether distinct from the eight large lateral canals which carried the ovarian bands. This canal system consisted of from three to five fine tubes, which sprung from the upper part of the peduncle, between each of the lateral canals, and passed outwards and downwards as a rarely anastomosing network, to join the circular canal bordering the mouth of the bell. No branches from it joined the lateral canals, as the latter were bordered on each side by the long ovarian bands. Throughout the whole supplementary system

in water recently brought from the sea. It must be slowly filtered through blotting-paper into a glass vessel capable of containing not less than three or four gallons, in which are placed a few fronds of *Chondrus crispus*, *Enteromorpha* or *Ulva*. A few Medusæ only should be placed in the vessel, and fed with very small pieces of mussel.

As soon as the planulæ appear they should be removed with a dipping-tube into a round glass shade inverted and filled with filtered sea-water from the larger vessel, to which a few drops of mussel-juice must be added daily, until it appears crowded with minute protozoa. The internal surface of the glass, and especially the surface of the water, should be examined daily from without with an inch lens, and as soon as each planula adheres to the inside of the glass, a thin cover of microscopic glass should be attached externally over its site with an interposed drop of glycerine, to ensure a flat surface, and the microscope, placed on a proper support, should be brought up to it. The light, the quantity of which must be regulated by a diaphragm of black paper, should be reflected from a plane mirror, and carefully adjusted to pass directly in the axis of the tube of the microscope. By this means the whole process of the development of the planula into the hydroid zoophyte, with the successive budding of the polyps, may be seen in a very beautiful manner. This process is carried out in a period varying with the genus from which the planula is derived. Thus, in *Sertularia pumila* and *Campanularia dichotoma*, the first young polyp is complete in a few hours; while in Hydractinia and Equorea, our patience is tried for several weeks ere the same event occurs. The planula of the Stegan-opthalmata, such as Chrysaora, Cyanea, and Aurelia, may be removed from the ovaries or marsupial sacs of the Medusæ as they lie exposed on the sea shore, and rarely fail to become developed into polyps or Ephyræ. In this phase of their development they remain for many years, if well fed and kept in a darkened place, and multiply rapidly by gemmation. They may, however, be forced to assume their medusoid phase, by exposing them, without food, in a small quantity of sea-water, to direct sunlight.

the presence of ciliary motion was indicated by the vibratory and onward movement of the milky fluid contained therein, and it is evident that its function is to supply nutrient material to the powerful muscular tissue of this rapidly swimming medusa.

As far as I know, no similar canals have been detected in any of the other Gymnopthalmata.

(2.) *On Acanthobrachia inconspicua*, T. S. W. (nov. gen. sp.)

Umbrella hemispherical, laterally compressed. Peduncle four-lipped, short. Lateral canals four; Tentacles eight; six long, springing from the sides of the margin of the umbrella; two abortive, placed at each end of the margin of the umbrella. Otolithic sacs eight, two accompanying each of the tentacular bulbs which do not spring from the lateral canals. Extremities of tentacles furnished with large prehensile palpocils.

This Medusa, probably the reproductive phase of a Campanularian zoophyte, was found in Granton Harbour in the summer of 1862. It is remarkable for the compression of its umbrella, the *circular* marginal canal of which presented an oval contour. The tentacles placed at each end of the oval, are very short, and attached along the border of the circular canal as far as one of the neighbouring otolites, as in Plate I., figs. 2 and 3 *a*. The long lateral tentacles, which are capable of being extended to twelve times the depth of the umbrella, are distinguished by the long spinous soft palpocils (fig. 4) which spring from their sides, and which are capable of being protruded from the ectoderm, and of adhering with singular tenacity to any object or smooth surface with which they come in contact, over which they spread themselves out in an irregular discoid shape, so that the animal can hang by its tentacles to the sides of the vessel in which it is confined. I have noticed the existence of similar exaggerated palpocils on the tentacles of a gymnothalmatous medusa in my paper on *Goodsirea mirabilis*. In both Goodsirea and Acanthobrachia, they are entirely unconnected with the existence of thread-cells which are absent on those parts of the tentacles from which the palpocils

spring. In my paper on Hydractinia, I have stated that the palpocil is a protrusion of the homogeneous and granular ectoderm and homologous with the prehensile processes of Actinophrys; and in the different zoophytic orders and genera their shape resembles the same processes in various Actinophrian forms. Thus, in Coryne they resemble so exactly the almost invisible palpocils of minute specimens of Zooteirea, that it is impossible to distinguish between them. In Hydra and the creeping planulæ of Hydractinia, they approach to those of Actinophrys. In Acanthobrachia they resemble the spreading lobular but still unbranched processes of some of the Rhizopods. While in Cydippe, as I have lately observed, the palpocil assumes a perfect pseudopodic type, being capable of complete retraction and rhizopodic extension.

(3) *Atractylis bitentaculata* (new. sp.), T. S. W. (Fig. 5.)

"Polypary creeping, retiform. Polyps club-shaped, nearly sessile, non-retractile, minute, each furnished with two erect tentacles."

Found on a Pecten shell dredged from the Firth of Forth near Inchkeith. The polyps of this zoophyte are very minute, and thickly clustered on a retiform polypary. They have the habit somewhat like that of *Lar* (Gosse), of quickly bending down the body until the mouth is brought close to the surface on which the zoophyte grows.

(4.) *Atractylis quadritentaculata* (n. sp.), T. S. W. (Fig. 6.)

Polypary creeping. Polyps, sessile, columnar, non-retractile, short. Tentacles, alternate, four; two long and depressed; two short, and nearly at right angles to the stem of the polyp.

This was found creeping along the side of a large vessel of sea-water, containing shells and zoophytes dredged from the Firth of Forth near Edinburgh. The two long tentacles were depressed, so as to touch the glass to which the zoophyte adhered. The shorter tentacles were occasionally absent. The bodies of the polyps were enveloped in a ball of extraneous matter adhering to a coat of glutinous colleto-

derm with which it and the scleroderm were covered, and which could only be removed by directing a strong stream of water against it.

(5.) *Coryne ferox* (n. sp.), T. S. W.

Polypary creeping. Polyp-stalks single, smooth. Tentacles, thick, short, having the capitate cluster of thread-cells scarcely larger than the width of the tentacle. Medusoids developed beneath the tentacles similar to those of *C. decipiens.*

This Coryne resembles *C. decipiens* (Dujardin) in the shape and mode of development of the medusoids, but it differs from that zoophyte in its more robust and clumsy habit. The tentacles of *C. decipiens* are long, tapering, and capped with large bulbs of thread-cells. Those of *C. ferox* are short, nearly of equal thickness throughout, and though they are surmounted with a cluster of thread-cells, the thread-cells are so few in number, that the tentacles can scarcely be called "capitate." A delicate epidermis of colletoderm passes over the whole body and tentacles of the polyp, which causes it to assume a dirty appearance, as it often serves to support a downy growth of very minute algæ. *C. decipiens* is the hardiest of all the hydroidæ; I have known a colony of it to live for six years in captivity, whereas *C. ferox* seldom survives more than a few days after having been removed from the sea.

III. *On* Ophrydium versatile, *Ehr.* By W. R. M'NAB, Esq.

The *Ophrydium versatile* is one of the most curious of all the infusoria, occurring as it does in large gelatinous masses of a greenish colour, which are sometimes adherent to the stems of aquatic plants, but often free, and floating on the water, like masses of frog's spawn, for which it has been mistaken. It is found in considerable quantity in several ponds near Edinburgh; and from its abundance in the Botanic Garden pond, the observations here recorded were made, an abundant supply being at all times at hand. The gelatinous masses contain great numbers of the individual Ophrydia, which

contract and expand in a very curious manner. The infusoria themselves are separated from each other by a small quantity of gelatinous matter, which, as it is secreted by each individual, appears as if cellular. The free extremity, where the mouth is situated, has a number of cilia placed round it, while the mouth has a lid, ciliated round the edge, which shuts down. The cilia form but a single band, which is reflected from around the mouth, along the edge of the lid.

If one of the gelatinous masses be placed in a watch-glass, in a short time all the animals escape. The individual Infusoria are, when fully expanded, about the one-hundredth of an inch in length. After the animals escape they acquire a second band of cilia, which enables them to swim with great freedom through the water. The individuals observed generally escaped at the end of eight or ten days, leaving nothing but a mass of jelly, which does not dissolve after two months' standing in cold water. Sometimes no second band of cilia appears, and then three furrows were seen running along the whole length of the body in a spiral manner, which gave a rotatory screwing motion to it, and enabled the animal to move backwards rapidly. The cilia being the propelling power, the animal moves with the aboral pole forwards. Near the oral extremity is situated the transparent vesicle or nucleus; this is quite visible when the animals are attached, but shortly after they become free it disappears. It breaks up into numerous small spherical vesicles, which are called the yolk-masses by Dr Balbiani. The researches of Dr Balbiani show that the contact of the oral extremity of two hermaphrodite Infusoria is necessary for the disappearance of the nucleus: this I have never seen in Ophrydium, although it may occur. Dr Balbiani's observations tend to show that the nucleus is the ovary, and the nucleolus the testis. All the observations made on the Ophrydium show that the nucleus produces the spherical bodies, or yolk-masses, which are developed into the perfect animals. The testis or nucleolus has not been observed in the Ophrydium, but in all probability it does exist, although it may escape detection without careful examination with a good microscope. The nucleus, as has been said, breaks up and dis-

appears; but in about fourteen days there are seen a number of small transparent vesicles little larger than the chlorophyll granules in the interior of the body. These vesicles increase in size, till at last the parent animal bursts, and liberates from six to ten spherical bodies, with a large nucleus occupying the centre of each, and two or three chlorophyll granules between the nucleus and the cell-wall. In a day or two the spherical body becomes capable of expanding and contracting slightly; and at one end several cilia appear, which is the oral extremity. The animals, increasing in size, soon become identical with the animals from which we started. When they appear to be full grown, they begin to show symptoms of division, which takes place in the direction of the long axis of the body. This division goes on with great rapidity; and as each secretes a small quantity of the gelatinous substance, a mass containing thousands of Ophrydia is soon formed. The secretion of a small gelatinous investment by each also shows the manner in which the cellular appearance of the mass is formed, by gritty particles getting between the joinings.

The nucleus of the Ophrydium has been described as composed of numerous small vesicles joined together in a moniliform manner; but this may be accounted for by supposing that the animal was observed when the nucleus had broken down, and liberated the spherical vesicles into the body cavity. This process is exactly similar to the endogenous multiplication of cells.

The liberation of the vesicles in all the specimens of Ophrydium examined was effected by the entire disintegration of the parent animal. This seems to differ from the observations of Dr Balbiani, who observes, "We see, therefore, that while in some Infusoria a nucleus appears *de novo*, after each reproductive act, to replace the old ovary, which has left no trace of its presence, in others it is formed anew from those parts of the same organ which have not been concerned in the production of generative elements. This reconstruction of the sexual apparatus seems to show, that oviparous propagation does not assign a term of limit to the propagation of these beings, as occurs in the case of a large

number of other animals, but that they continue to live, still preserving the power of producing fresh generations." This may hold good for some Infusoria, but it does not seem to hold for Ophrydium, because the liberation of the spherical vesicles is not effected by any other means than the total disintegration of the body of the parent animal—thus, we would think, resembling the process in those animals in which the deposition of ova is the last act of their existence.

I would only further remark, that we may consider—1*st*, That true reproduction does take place in the Infusoria, as pointed out by Dr Balbiani; 2*d*, That the nucleus plays an important part in this process, furnishing the yolk-masses which are afterwards developed in the spherical vesicles, which are in this case the young Ophrydia; 3*d*, That there is an alternation of generation with fission; 4*th*, That the masses are the entire product of a single spherical vesicle, which we must regard as an ovum; and, 5*th*, That we may suppose that many of the free so-called Infusoria are the larval or imperfect forms of the true or fixed ones.

Wednesday, March 25, 1863.—James M'Bain, M.D., R.N., President, in the Chair.

The following Donations to the Library were laid on the table, and thanks voted to the Donors:—

1. Proceedings of the Royal Society, London, Nos. 51 and 52. Vol. XII.—From the Society. 2. Transactions of the Royal Irish Academy. Part 2, Vol. XXIV.; Science, 1862.—From the Academy. 3. Jahrbuch der Kaiserlich, Koniglichen Geologischen Reichsanstalt, 1861 and 1862; XII. Band. Nro. 3, Mai, Jun., Jul., Aug., 1862.—From the I. R. Geological Institute of Austria. 4. Transactions of the Botanical Society, Edinburgh. Part 2, Vol. VII., 1862.—From the Society. 5. Canadian Journal of Industry, Science, and Art, New Series. No. 42, November 1862.—From the Canadian Institute, Toronto.

The following Communications were read:—

I. *Notes on some Surgical Homologies.* By A. M'K. Edwards, Esq.

II. *On the Vertebroid Homologies of the Cranium in* Vertebralia *or* Osteozoa, *and the analogous Homologies of the* Annulozoa, *or* Articulata. By William Macdonald, M.D., Professor of Natural History, St Andrews. (With Table.)

Ever since the promulgation of the grand and independent inspirations of Goethe and Oken on viewing the bleached

cranium of a deer or sheep in the Black Forest, which impressed them with the resemblance the cranium bore to a series of vertebræ more or less fused together, the theory of a unity of organisation, traceable throughout all the vertebrate and articulate classes, has been wrought out downwards to the lowest EOZOA or ACRITA. The main object of this communication is to point out the homologies which appear in the human cranium, as the first part of the subject, and especially, to determine the true homologies of the different types from man to the lowest ichthyia or osseous fishes, and afterwards those analogous homologies of SCLERODERMS among the ANNULOZOA and ARTHROZOA (the Articulata.—CUV.)

A few changes in the usual terms of the anatomical school will be required for the clear elucidation of this important subject. *Skelon* will be substituted for Endoskeleton, and the different segments will be styled Skelotomes. Instead of Exoskeleton or Scleroderm, *Scleron* will be used, and Sclerotome for any segment seen in the Arthrozoa and Annulozoa. *Somatome* will include a segment of both *skelon* and *scleron*, together with the visceral or *splanchnoskelon*, and the soft parts connected with them. These terms are slightly modified from those proposed by Professor Goodsir.

The characteristic difference distinguishing the VERTEBRALIA from all other members of the zoological scale is drawn from the existence of a central stem or *kaulon*, usually styled the Spinal or Vertebral column. I restrict this term to the stem formed by the centra or bodies of the vertebræ continued through the basicranium, having sometimes a mesospine on its ventral aspect. On its dorsal aspect, the perineural tunnel protecting the myelon or spinal marrow, is formed by the coalescence of the neur-arcs on each side, firmly anchylosed to the individual skelotome of the kaulon, and extending backward to unite in the neural spine.

These Neur-arcs are formed of three distinct parts, like all other laminæ—

1. The *Pedicle* fused into the vertebræ, and forming part of the aperture for transmitting the spinal nerves (*trous des conjugaison*).

2. The *Lamella*, generally the largest part, with the tubercle

and flat portion extending downwards and backwards in man, and, at the junction with its fellow of the other side, gives support to the neural spine. On the edges of the lamella the articulating surfaces, allowing a slight motion, are met with. The extension of the epiphysis of the tubercle has been described *incorrectly* as the transverse process, as it is only connected with the centrum or vertebra by means of the pedicle.

3. The *Neural Spine* is formed by the extension of the lamella meeting in a spine. Restricting the term *Vertebra* to the *centrum*, the neur-arcs form the *metavertebræ*, while the laminæ developed on the ventral aspect converging to the sternum form the *provertebræ*. These are constructed on the same plan as the neur-arcs, and may be called *Hæm-arcs*, as enclosing the trunk and main branches of the vascular system.

The Hæm-arcs also consist of three parts—

(1.) Pedicle, or head and neck of the rib, normally articulated opposite the intervertebral space, partly on each of the adjoining vertebræ, and protecting the trunk of the spinal nerve issuing from the neural tunnel beneath it.

(2.) The lamella or body of the rib; its tubercle rests on that of the neur-arc of the next lower vertebra.

(3.) The spine or cartilage of the true ribs is attached to the sternum, where it exists, or coalesces in the median line.

It may also be assumed that there exists a *provertebral stem* or *prokaulon* as exhibited in the sternum of mammals, birds, and reptiles, which Geoffroy St Hilaire termed *Sternebræ*, as well as *metakaulon*, or *dorsibræ*, represented in the interspinous bones of ichthyia or osseous fishes.

The splanchno-skelon, represented by the hyo-branchio-stegal and branchial system, belongs to the prokaulon or provertebral system, which includes the prothoracic, mesothoracic, and metathoracic wings of the insect and the ventral fins of fishes.

The provertebral trunk of mammals consists of there kistæ or thoraces.

I. Prothorax or prosopo-kista includes the bones of the face or mandible.

(i.) Rhinal or prenasal arcs.
(ii.) Incisive or premandibular arcs.
(iii.) Mandibular arcs.
(iv.) Palatal or postmandibular arcs.
(v.) External pterygoid arcs.
(vi.) Internal pterygoid arcs.
(vii.) The velum or soft palate.

The hard palate, like the carapace of the crustacea, is formed by the union of ii., iii., and iv. hæmarcs.

II. Mesothorax or pneumo-kista is formed by the ribs meeting in the sternum or prokaulon, enclosing the hyo-branchial splanchno-skelon.

III. Metathorax, or aidoio-kista, supports the hypogastric and pelvic viscera.

Encircling these there are three limb zones or girdles, each having a pair of members or limbs articulated to them.

I. The temporal zone, formed by the squama-temporis—zygoma and malar bone firmly binding the procranium and metacranium over the mesocranium. In the glenoid cavity the head of the maxilla or condyle is articulated, forming the 1st laminar portion or pedicle; 2d, the angle or tubercle and base of the maxilla—lamella; and, 3d, the mentum or incisive portion or spine.

II. The humeral zone or scapulo-clavicular.

From the glenoid cavity.

1st, The brachium or pedicle depends;
2d, The antibrachium or forearm;
3d, The carpo-digital completes the lamina.

III. The Coxal Zone or Pelvis.

1. The femur is articulated in the acetabulum.
2. The tibia and fibula form the lamella, but in this case the tarsus and toes may be viewed as a repetitive member.
   (1.) The astragalus.
   (2.) The calcaneum and navicular.
   (3.) The toes.

Perhaps the same arrangement should be adopted with the carpo-digital.

After these preliminaries we may proceed to the analysis

of the cranium, placed on the summit of the *kaulon*, where the first and second cervical vertebræ have a different relation to one another from what is seen in the lower vertebræ: in order to give the extended motion enjoyed by the human cranium equivalent to the universal joint, the body of the axis, with its narrow lamellar tubercle and very prominent spine, has a strong odontoid process developed on the upper surface of the centrum, which intrudes, and in a manner replaces a large part of the body of the atlas, here reduced to a mere bony ring having a meso-spine on its ventral surface, while the axis is retained by a strong ligament behind it, completing the floor of the neural tunnel. The posterior ring of the atlas has the lamellar tubercles or transverse processes much produced, but the neural spines very small, greatly contrasting the axis in all particulars.

The axo-atloid relation is carried out in the basicranium, where each centrum has a double perineural arch in the following ascending order:—

Bivertebræ.		Metavertebræ.
I. Basi-occipital.	⊕	*P.* Condyloid. *L.* Edge of Foramen magnum. *S.* Sub-occipital spine.
II. Basi-otic.	⊕	*Axoid.* *P.* Hyp-otic and Mammilla *L.* Epi-otic. *S.* Wormi-otic. *Atloid.* *P.* Pro-otic and Mastoid. *L.* Parietal.
III. Basi-sphenoid.	⊕	*Atloid.* Alæ majores—Orbito-sphenoid. *Axoid.* Olivare. *P.* Optic. *L.* Ant. clinoid. Alæ Ingrassii.
IV. Ethmo-frontal.	⊕	*Atloid.* *P.* Supra-orbital plate and Superciliary ridge. *L.* Os frontis. *Axoid.* Ethmoid and turbinals.
V. Apocranial.	⊕	Nasal protuberance and Ossa nasi.

The relation of these vertebroid skelotomes of the cranium to the encephalon and the cranial nerves is very important, and deserves more notice than can be given in this hasty communication to the Royal Physical Society. Had time permitted, the vertebral analogies could be shown by the intervertebral transmission over the pedicle. This part of the subject, with the evidence afforded by development in the fœtus, will form the subject of a future communication.

Without attempting to examine fully the course of development of the human cranium, a slight sketch is necessary to show the coincidence between the fœtal and adult condition.

Professor Huxley has assumed that there are three states or conditions of the human fœtal cranium.

1. The membranous or vesicular cranium, when the skelon is entirely membranous, consisting of investing tissue enclosing the centrochord (noto-chord) between the neural and hæmo-splanchnic axes, which consists of mere cellular substance within a structureless sheath, forming a primitive centre around which the bodies of the vertebræ are so placed as to afford a floor or basement for the cephalo-myelon to rest upon, over which the neur-arcs raise an arched tunnel by the anchylosis of the neural spinous process of each metavertebral skelotome in adult condition.

II. The chondro-cranium, shortly after fœtal development has commenced, may be traced, at several points, around both the cephalic and spinal centrochord in the cartilaginous square masses observable on each side, and which appear to be the tubercles of the neur-arcs, which are first ossified, and from whence ossification of the pedicle extends to the centrum vertebræ, and in the other direction completes the lamella, and ultimately terminates the spinous processes. In the basi-cranium a similar process may be observed around the foramen magnum and onward.

III. The Osteo-cranium, commencing with the basicranial axis, in the same order as when describing the chondroskelon.

(i.) The *Occipital Bivertebra* begins to show points of ossification before they appear in the vertebral kaulon. At birth the occipital bone consists of separate pieces: 1. Basilar; 2. Condyloid; 3. The cerebellar fossæ, formed in membrane about the same time that the wormi-otic spine appears in two points. The different parts of the occipital bivertebra are not completely ossified before the sixth year.

(ii.) The *Basi-otic Bivertebra.*—The centrum 5 is formed by the anterior part of the basilar process (*posterior clinoids*),

which is subsequently so incorporated with both the basi-occipital and sphenoid, that Sœmmering described them as a single bone *spheno-occipital or basilar* in the adult condition of the cranium. The petrous is early developed, and besides forming the hyp-otic 6 and 9 the pro-otic, contains the otic capsule. The ossification begins in these in a chondrous state, about the same time as the ossification of the kaulon. The parietals are ossified in membrane.

(iii.) The *Axo-prespheno Bivertebra, or the Anterior Spheno-orbital* (Beclard) ossifies very early in fœtal life, at the margin of the foramen opticum, and extends along the ingrasial wings 18. These are afterwards united in the centre. Towards the close of fœtal life this vertebra is closely united with the sphenoid, and is usually in Anthropotomy described as part of that bone.

The *Atlo-sphenoid* centrum 12 with the rostrum 12′, and the pedicles of the wings, are ossified in cartilage, but the ala major results from membrane. The ossification begins in the sphenoid soon after the occipital, and is developed from many centres. Beclard divided these into two classes:—1. The posterior or spheno-temporal includes the ala major 16, where the first nuclei are seen anterior to the foramen rotundum, from whence the ossification extends outwards and upwards into the alæ majores, and downwards into the pterygoids 36, 37. About the same time there are two ossific points for the centrum 12, and the lateral projection, as described by Meckel, and copied in "Quain's Anatomy" (fig. 26, b. 5).

(iv.) The *Ethmo-frontal Bivertebra.*—The perpendicular plate of the ethmoid extends through the atlo-frontal, arising from the frontal protuberance, and forming the axoid portion. The ossification of the frontals or the atloid portion commences early in membrane, by a central point in each half. They are separate till birth, and in females often remain so during life.

(v.) The *Apo-cranial Bivertebra* is formed by the nasal promontory 22, with the nasal spine continued into the septum nasi 24 axoid.

The atloid consists of nasal 23, cartilage 24, rhinal 25.

Before concluding this hasty communication, the attention may be directed to prepared disarticulated crania of the cod, as representing the osseous fishes.

I. That by Mr Flower of London, according to the views of Professor Owen.

II. That prepared by Mr Davies, of the Natural History Museum, Edinburgh, according to the system advocated in this paper.

It will be seen that in the No. I. Professor Owen has omitted the occipital vertebra altogether, having mistaken it for the atlas, but as it closes in the par-encephalic or cerebellar cavity, as shown in No. II. in its proper relation with the distinct cranio-vertebral characters. This, of course, renders the numbers used by Professor Owen incorrect, as may be seen by referring to the tables where the names adopted in this paper are so arranged as to show the synonyms of Owen, Huxley, Bertrand, and the Nos. of Cuvier, where the homologous bones, according to the different authors, can be identified. (See Table, p. 49.)

On the Thoracic Zones and Limbs of Osseous Fishes.

The temporal zone 46–48 inclusive, and its limb, is attached to the anterior margin of the scapula 53, described as the *tympano-mandibular arch* (Owen); the scapula or epitympanic (Owen)—the suspensorium (Huxley)—supporting the opercular bones of fishes.

The *temporal* of Cuvier will be found to represent the *mammal temporal* as well as the *scapula*, advanced and articulated with the mastoid (10). It is more varied in its shape, and, besides the *coracoid* and *glenoid* processes for the union with the *clavicle* (54) and the *brachium* (55), it projects another forward to support the *temporal* 46, 47, and the *condyle maxillæ* (49), all connected by squamous suture.

Professor Owen has hazarded a wilder homology in regard to the pectoral fin of the ichthyologist. In this he follows

Cuvier, who, in the subject of homology, was perhaps the worst guide who could be taken, as by his eloquence and influence in the Institute having defeated the brilliant Geoffroy St. Hilaire on his fanciful homology of the opercular apparatus, he was inclined to repudiate homology altogether.

Cuvier, misled by the idea that the pectoral fin was the homologue of the anterior extremity, fancied that the coxal zone 58 was the *supra-scapula*, and the *femur* 59 was the *scapula*, thus including two distinct and separate portions of the skelon in the construction of one bone, while in one of the bones of the leg the *tibia* 61, has to represent two bones.

The most objectionable part of the homologies of Owen, Cuvier, Huxley, &c. &c., is the confusion caused by including in fishes the scapulo-clavicular or humeral zone with the arm as bones of the cranium, merely from their being in close connection with it, instead of being placed lower down the trunk, as in mammals.

I. The Pro-thoracic or Temporal Zone 46, 47, 48, is misnamed as in connection with the tympanum as well as 49, which will be found to be the condyloid part of the maxilla, which is completed by 50, 51, and 52.

II. The Mesothoracic or Humeral Zone 53. The scapula is also included in the tympanic series, and supports 54, 55, 56, 57 the opercular bones of Owen, and the bones of the internal ear, according to Geoffroy St Hilaire, but which will be found anatomically to be homologues of the scapulo-clavicular zone, and anterior or respiratory limb of mammals—the skelon of the *Lophius piscatorius* shows this by having the fin rays developed, though not protruding through the skin.

III. The Metathoracic or Coxal Zone. Cuvier and the continental comparative anatomists have here entirely misled Huxley, Owen and his followers, by describing the pectoral fin of the ichthyologists as the supra-scapula, the scapula, arm, and hand, whereas 58 is the coxal or pelvic zone, and from 59 to 67—the thigh, leg, tarsus, and toes. This must be cleared up before any system of homology can

be correctly assigned between the ichthyic and mammal types. The first approach is made in the chondrous skelon of the rays, where opercular bones are in relation to their proper function, as the arm, supported on the scapulo clavicular zone, having the hand greatly enlarged—in fact, forming the large portion of the body of the skate—while the pectoral fin is supported by the coxal or pelvic zone near the commencement of the tail, as the claspers in the male.

The crowding of the limbs about the cranium of fishes has been pre-typified in the invertebral Annulo-zoa and Arthro-zoa, which are neurapods, from having their legs and feet so bent as to appear on the neural aspect; the osteo-zoa are hæmapods, from having their feet and legs on the ventral or hæmal aspect.

The insects and crustacea, with their neural axis or myelon below both the visceral and hæmal axes, may be said to walk on their back, and have all the thoracic rings closely placed at the head, the œsophagus passing through the neural ganglia representing the brain, in its way to the oral opening, which, in all non-sessile animals, opens towards the ground on which they walk. In both these classes the oral apparatus consists principally of the early representatives of the cranial metavertebral neur-arcs.

The Antennæ	=	VI. The Apocranio-Nasal.
The Labrum	=	V. Frontal.
The Mandible	=	IV. The Sphenoid Alæ.
The Maxilla with its palpi	=	III. The Parietal.
The Labium	=	II. The Wormi-otic.
The Mentum	=	I. The Occipital.

These represent the metavertebral neur-arcs.

The invertebrate scleron has neither a central kaulon, nor the metavertabral nor provertebral pedicles; but the provertebral lamellæ and spines meet over the dorsal vessel or hæmaxis, resting its tubercle on that of the metavertebral lamellæ, whose spines are united under the neuraxis.

The prothoracic or temporal zone supports the prototype of the vertebrate maxilla.

The mesothoracic ring supports the arms, and represents

the humeral zone, which, in insects, carries on the hæmal upturned aspect, the first pair of wings, appendages of the respiratory organs, whether lungs, branchiæ, tracheæ, &c. &c.

The metathoracic ring supports the hind legs, and the second pair of wings on the hæmal aspect, representing the ventral fins in fishes.

In crustacea the number of legs from the mesothoracic and metathoracic rings are doubled; the provertebral carapace homologous with the mammal palate completely covers the centres of the nervous, digestive, and vascular systems; these rings are incomplete.

A portion of Professor Huxley's "Lectures on the Vertebrate Skeleton" has appeared in "The Lancet," illustrated by diagrams in wood. These have been little consulted, from being inconsistent with the vertebral scope of this paper, based on the unity of organisation and the vertebroid homologies of the animal kingdom. "Who can decide when doctors disagree?"

On Development as the basis of Homology.

Agassiz, Goodsir, Huxley, and others, maintain that the study of the progressive development of the various laminæ composing the skelon is the only basis on which the determination of accurate homology can surely rest; and Cuvier long ago propounded the same dogma when enumerating the bones in each species of the mammalia. "We must descend to the primitive osseous centres as they exist in the fœtus." Owen showed the inapplicability of this rule, as the human brachium should be counted three bones instead of one, and in like manner four would be enumerated instead of the femur. The Cuvierian rule fails by not distinguishing between the ossific points which permanently complete the bone and those which only typify parts of bones which are in the fœtal condition separate, in order to facilitate ossification of individual bone, as the cases above referred to. The study of development having comparatively but a restricted sphere among anatomists and naturalists, little advantage can safely be taken of it, as in the present state of our knowledge it seems to have led as much to confusion as to

clear views. It is safer to examine the progress of ossification in the adult species, as seen in the animal scale.

Keeping in view the simple scheme of the foregoing communication where the term "vertebra" is restricted to the kaulon or central stem of the vertebral column and the peri-neural or meta-vertebral portion of the segment, restricted to the neur-arcs of the tunnel of the cerebro-spinal axis and the peri-splanchnic and hemal or pro-vertebral part of the segment, and instead of the complex apophysal terms of Owen using the common terms of the medical schools of anatomy for the elemental component parts of the laminæ, whether simple as in the ribs and maxilla or lower jaw, or in those more complex laminæ of the limbs,—where the carpus and tarsus seem to be the repetition of the laminæ, branching from the distal joint of the lamella or second part.

The vertebrate skelon consists of a central chain of bones in its early condition, discoid in form, enveloped in a membranous tissue forming the centro-chord as exhibited in the Lancelet,—(*Amphioxus lanceolatus*—*Branchiostoma*—Owen). This lowest vertebrate type was classed as an invertebrate annelid till it was shown by Goodsir (Roy. Soc. Edin. Transactions, xv. 1), and Owen (in his Lectures, ii. p. 171), to possess a feeble median linear centro-chord arrangement; most distinct anteriorly, where it is cylindrical, it is continued to the very point of the animal, beyond the early development of the olfactory and optic nerves, the first dawn in vertebralia of the Mes-encephalon and Pros-encephalon, and accompanied by the trigeminal nerves from the Par-encephalon or upper part of the Myelon. The centro-chord supporting the neural axis and placed above the visceral and hemal axes, instead of lying below as in the invertebralia, places the Lancelet in a higher relation than its former associates—the Entozoa.

The centro-chord, though not the spinal column, is admitted to be at least the nucleus of the chain of vertebral centres, which has been received as proving the vertebral condition of the cranium, first propounded by Goethe, Oken, Spix, Dumeril, and others; and since their day, in this

country, by Grant, Owen and a host of his followers, and not disputed till lately by Huxley, in his lectures to the Royal College of Surgeons, first reported as they were delivered, but without his revisal, in " The Lancet," and now being published in the " Medical Times," arranged and corrected by himself. One object of the talented Professor seems to be the repudiation of the Goethe-Oken vertebrate theory of the cranium. Their brilliant inspiration, if it were no farther tenable than giving a good and clear orderly sequence of arrangement of the multitudinous collection of variously shaped bones, could have been profitably used by Professor Huxley in rendering his excellent lectures more lucid, and thus adding another tribute to the illustrious Germans above named, while he could have introduced the later discoveries of Rathke, Reichart, Hallman, and his own, with more advantage to the farther advancement of this very important theory.

It is much to be regretted that he did not follow up the vertebral argument more completely. There are some parts of the subject where development would be useful in the establishment of homology, still it is not always to be depended upon. Nor are we always to expect that those bones which appear in the mature cranium as single may not arise from more than one ossific centre. Owen has remarked the danger of development multiplying the number of bones by the number that appeared in the fœtal condition of the mammal, or in the lower skeleton of the fishes.

The temporal bone, anthropotomically described, is a marked instance of this, and consists of a vast number not only of osseous elements but distinct members of the skelon. The human temporal zone supporting the maxilla, or lower jaw, is formed by the squamous plate and zygoma, as far back as the middle of the glenoid cavity, bounded by the glasserian fissure, all the rest of the bone being connected with the basi-otic vertebra—the pro-otic or petrous bone forming the pedicle of the petro-parietal neur-arc, having the mastoid process as the tuber lamellæ, while the hyp-otic, extending outwards to the digastric mammilla is the tuber lamellæ of the wormi-otic neur-arc. The interval between these is

filled up by auditory or otic sense capsule, containing the labyrinth or internal ear, with the tympanum and vaginal process, in which the styloid is inserted; this very complex bone, though single in human anatomy, contains no less than part of two vertebral neur-arcs, and the auditory apparatus, in addition to the temporal limb zone; at the same time forming the barrier between the cerebral and cerebellar cavities.

Fully impressed as we are with the importance of the study of development in determining the homologies of the skeleton, it may be doubted whether a sufficient acquaintance with it has yet been acquired to enable us to trust to it as the only sure guide. An erroneous theory of fœtal development cannot be expected to correct a mistaken homology, however supported by names distinguished in science.

Without presuming to maintain that the homology here sketched will be received in all its details, it may be fearlessly maintained that no sound homology in fishes can be sustained, without adopting some of the suggestions of the foregoing communication, especially as regards the opercular bones and pectoral fins in fishes—in regard to which Cuvier, St Hilaire, Owen, Huxley, &c. &c., have completely misapprehended the homology—in the study of a rather complex subject, while, at the same time, it allows the fullest scope for speculative interpretation of the laws of organic development.

It is generally admitted that the vertebral column is developed on the *Chorda centralis*, but that the first traces of ossification in the embryo are the square bodies seen on each side of the linear groove of the *Blastoderm*, " which eventually become the middle region of the head or mesocranium, and the *dorsal laminæ* produced, extending forwards or backwards like parapets on each side of the primitive groove, and lay the foundations of the lateral walls not only of the skull but of the spinal column. Very early the boundary between the skull and spinal column is laid down. The proto-vertebral elements increase in number from the mesocranium *backwards* throughout the whole length of the spinal column, and *forwards* to the tip of the cartilage of the nose."

"The dorsal laminæ first coalesce in the middle cephalic region, extending forwards and backwards. The cephalic canal is separated into three distinct dilatations or cerebral vesicles, of which the anterior is the largest." Subsequent flexure of the vesicles divides the cavity of the cranium into pro-cranium and meso-cranium, at angles to each other; as development proceeds the meta-cranium and para-cranium cover the posterior lobes of the brain and cerebellum. The neur-arc forming the chondroid tunnel of the cerebrum and cerebellum, from the posterior occipital through the wormian and masto-parietal, coalesce with the ethno-frontal, and cover the ali-sphenoid and spheno-orbital. The basi-cranium, composed of, (1.) basi-occipital; (2.) basi-otic, or basilar; (3.) basi-sphenoid, or basi-olivare; from the *rostrum sphenoidis* the chondroid plate of the ethmoid and nasal is prolonged. This chondroid condition is well seen in the cranium of the Salmonidæ, where the osseous frontal and parietal are easily forced off the cartilage, and the long basi-sphenoid is equally removable from the chondroid basi-cranium, which extends into the incisor or pre-mandibular palate, sometimes misnamed the vomer. Agassiz maintained that the centro-chord did not extend beyond the *sella turcica;* and Huxley seems to adopt the same opinion, though, strangely enough, he admits that in the Lancelet it extends to the utmost length of the animal, beyond the termination of the myel-encephalon. It may be as well to remind the student that the relation of neuraxis and the hæmaxis to the digestive or intestinal tube is completely different in the articulate and vertebrate classes. In the segment of the crustacean and entomoid classes, the neuraxis is contained in a small canal below formed by the neur-arcs, but without any kaulon or central stem, and lies beneath the digestive or intestinal canal. The anterior or oral termination, passing through esophageal nervous ring, being the type of the par-encephalon behind with the auditory apparatus, while the mesencephalon and prosencephalon, with the optic and olfactory sense capsules, lie before. Thus the pharynx and mouth of the invertebral pass where the pituitary body and infundibulum (possibly the typical rem-

nants of the mouth of the invertebrals), occupy the sella turcica, the ethmo-frontal forming the labrum, the sphenoid and presphenoid the mandible, the parietal and wormi-otic the maxilla, and the occipital the labium. The hæmaxis runs along the upper part of the segment above the visceral cavity.

In the vertebrate classes, the relation of these axes is inverted. The neuraxis, above the intestinal tube, which is no longer found to pass through a ring in the neuraxis after the vertebral kaulon has been interposed, and the hæmaxis in the visceral cavity on the ventral aspect.

III. *Notes of a Fireball (or supposed Aërolite) recently observed near Auchterarder, Perthshire.* By JOHN ALEXANDER SMITH, M.D.

In the beginning of the month of February the following notice appeared in the Edinburgh newspapers :—

"AËROLITE.—A few days ago, while Lieutenant-Colonel Hunter of Auchterarder was out taking a walk over his estate, he saw an aerolite descend upon the farm of Drumtersal, occupied by Mrs M'Ewan. The sun had just gone down, and the sky was clear at the time. He describes its appearance as strikingly beautiful, exhibiting a most brilliant light, not unlike a red-hot twenty-four pound ball. It fell slowly to the ground, and at the same time a larger body passed over to the north east, in the direction of Trinity Gask. The Colonel, who was within a few hundred yards of the one which fell, marked the place of its descent, and it was got two days thereafter by his gamekeeper. At the place where it was found, the grass was burned up for a few inches around. It is now at Auchterarder House. It weighs upwards of ten ounces, and appears to have been detached from a larger mass. Another aërolite is said to have fallen near Stirling on the same evening."

Lieutenant-Colonel Hunter has since favoured me with more correct details of the fall of this fire-ball. It occurred, he informs me, on Tuesday, the 27th of January, at five minutes to 5 P.M. The day had been beautifully bright with sunshine; the sun, however, had set for eighteen minutes, but it was still full daylight, when his attention was attracted by the descent of a luminous body, which was most brilliant. Its fall was nearly perpendicular, and had all the appearance of a hot twenty-four pound cannon-ball. It fell apparently towards a lea field; and Colonel Hunter's gamekeeper, who happened at the time to be at some distance off in another direction, also saw it fall apparently in the same field; and,

43. Tuber lamellæ	*	39. Epi-hyal				37.
44. Styloid	P	38. Stylo-hyal				29.
45. Branchiostegal rays		44. Branchiostegal				43.

LIMB ZONES AND THEIR LIMBS.

Prothoracic, or Temporal Zone.

46. } Glenoid	L	26. Meso-tympanic (?)		Symplectic		31.
47. }	T	27. Pre-tympanic				27.
48. Zygoma (fishes)	T	12. Post-frontal				4.
49. Condyle maxillæ ,,	P	28. Hypo-tympanic				26.
50. Articulo-coronoid ,,	L	29. Articular				
51. Tuber lamellæ ,,	*	30. Angular				
52. Dental ,,	LS {	31. Splenial 32. Dental				

Mesothoracic, or Humeral Zone.

53. Scapula	P	25. Epi-tympanic				23.
54. Clavicle	LT	34. Pre-opercle				30.
55. Brachium	P	35. Opercle				28.
56. Cubit	*L	36. Sub-opercle				32.
57. Carpo-digital	T	37. Inter-opercle				33.

Metathoracic, or Coxal Zone.

58. Ilio-pubic (human)	LT	50. Supra-scapula				46.
59. Femur	P	51. Scapula				47.
60. Patella	*	52. Coracoid				48.
61. Tibia }	L	58. Epi-coracoid				49.
62. Fibula }					{	50.
63. Astragalis (tarsus)						
64. Calcaneum ,,		54. Ulna				52.
65. Navicular ,,		55. Radius				51.
66. Cubo-cuneiform ,,		56. Carpus				64.
67. Metatarso-digital ,,		57. Metacarpal phlanges				65.

after twenty-four hours had passed, with heavy rain, he was so impressed with the truth of the fall, that he went to see if he could discover anything in the field. He was soon attracted by the peculiar appearance of a stone which lay in a prominent position in the grass, quite in the place where the meteor seemed to him to fall. The stone had a sulphureous smell, and the grass around it was blackened; it was twelve ounces in weight, and was lying on the surface of the ground. The stone was dry and crumbly in its nature, and when handled gave off large dusty particles. It measured 5 inches long by 3 across, was about 1 inch in thickness, and was hollowed out on one side, as if it had scaled off from a larger body; its inner portion had also a metallic appearance. Colonel Hunter being no mineralogist, was naturally anxious to learn something about this rather peculiar-looking stone, which his servant had found in the very place where the fire-ball was seen apparently to fall; he accordingly gave part of it to a neighbouring chemist for examination, and was furnished with a detailed analysis. The result of this examination having been published in the Edinburgh newspapers, I quote from them the following particulars:—

"*The Recent Meteor discovered in Strathearn.*—The meteoric mineral discovered by Colonel Hunter is formed of layers, covered with laminæ of iron pyrites of a beautiful yellow colour, and metallic lustre. Some of the layers are crystalline, having a black metallic appearance, others are massive and friable, of red and grey colours, interspersed with bright crystalline specks. It is not magnetic, but has a strong sulphurous smell; its specific gravity is 2·360. When subjected to a red heat, it is changed into a brown porous mass, like the sesquioxide of iron, which shows that it must have been in a state of fusion so long as it retained the electric fluid in a condensed and intense form, and in cooling assumed a crystalline structure. Had it continued in its original state when sustained and carried along by the electrical energy, which possesses a most intense heat, its appearance would not be altered by subjecting it to the heat of a common fire. I have analysed this meteorolite, and find it to be composed of the following materials:—

Sulphuret of Iron, ...	33·25
Sulphuret of Nickel, ...	17·22
Oxide of Iron, ...	15·40
Carbonate of Iron, ...	10·00
Magnesia, ...	10·13
Silica, ...	14·00
	100·00"

In answer to further inquiries, Colonel Hunter informed me he was about 1000 yards distant from the falling body, and that he heard no report or sound whatever accompanying its fall; indeed, he says, its noiseless steady descent was most startling. At the same time another luminous body passed to the north-east over one of his fields where people were at work; this one, most unaccountably, he did not see, but fancies it might be the body from which this fire-ball is supposed to have fallen; at least his gamekeeper, who, as already mentioned, observed the body fall, states that he saw apparently the disruption of the meteor—a portion falling to the ground, and the rest proceeding onwards on its course.

As no report of any kind had been heard when the meteor was seen to fall, I was very doubtful of a stone-like body having fallen; a loud report being the general concomitant of the fall of an aërolite. I fancied that if any fall had taken place, the meteor might have consisted of gaseous matter or have been due to electric agency; the resistance of the atmosphere to its rapid passage having been too slight to cause any noise, or the appearance might have been simply illusory, and caused by the passage of a meteor at a distance too great to have been audible. I was aware, of course, of the danger of any peculiar or unusual looking stone lying near the place where an apparent fall had taken place, being picked up as the actual body that was seen, and believed at least, to have fallen there.

The published analysis, however, was against this view of the case, and Colonel Hunter politely forwarded to me the mineral mass for examination, and also some of its broken portions, to allow of the correctness of the analysis being tested. On examining the stone I found no traces of the dark-coloured outer coating or skin which exists on ordinary meteoric stones, depending, it is believed, on the fusion of their surface by the heat evolved in their passage through the atmosphere; but instead, the surface was rough and irregular, showing on one side various cubical masses of coal, and on the other the coal-like matter projecting in some places through a series of thin layers, apparently of white sulphuret of iron, white iron pyrites. The specimen speaks

strongly of its relation solely to the earth, and especially to the coal formation; indeed, it appears to be simply a weathered portion of one of those veins or thin seams of iron pyrites which are so common in our beds of coal, having been probably brought, with the manures, to the field where it was afterwards found. I showed the specimen to various friends, and they agreed with me there could be no doubt of its being simply a mass of white iron pyrites. The existence of the sulphureous smell in its gradual decomposition after continued exposure to the weather, was of course to be expected from its composition as a sulphuret of iron; and the same decomposition would also account for the blackened appearance of the vegetation round the crumbling mass of coal and pyrites.

The broken portions of the stone I put into the hands of our member and well-known lecturer on chemistry, Dr Murray Thomson, telling him nothing of its history, and requesting to know if it contained any metal besides iron; and was favoured with a reply, stating, he had made a lengthened examination of the substance sent him, and could detect no traces of any metal except iron. I then informed Dr Murray Thomson of the chemical analysis which had been made, and the reported discovery of nickel in the mass, and have since been favoured with the following notes:—

"Having been asked by Dr Smith to examine some powder which appeared like sulphuret of iron, with a request that I should look for other metals than iron, I did so, but was unsuccessful in finding anything else than iron and sulphur, and a little siliceous matter. Lead, copper, arsenic, manganese, alumina, cobalt, nickel, as well as tin and magnesia, were specially looked for. I could not, however, detect any.

"Dr S., since I reported this result to him, has showed me an analysis of the mass, in which it is stated that a large amount of nickel was found; as this result surprised me much, I have again carefully tested the substance for nickel, but was again quite unsuccessful in finding any."

In the newspaper paragraph quoted at the commencement of these remarks, it was stated that another meteor had fallen the same evening near Stirling.

Colonel Hunter informs me this was believed to have occurred at Plean, to the south of Stirling, on the same day and hour, 4·55 P.M., as the one seen by himself, giving as his authority the "Stirling Journal." It is probable that it was the same meteor which was seen at both these places, the direction of its course being, as already stated, from south-west to north-east, the very line which would connect them together.

Other meteors were observed at various places in the beginning of the month of February, and have been noticed in the different newspapers. These notices all refer, of course, to luminous appearances, greatly larger and more brilliant than the usual and well-known "shooting stars," as they have been designated. At a time when illuminations and fireworks were so much talked about and experimented upon, preparatory to their full blaze on the 10th of March, on the auspicious occasion of the marriage of the Prince of Wales, some caution, of course, was necessary in setting down every unusual luminous appearance seen at night to the agency of meteors; still there seems no reason to believe that any of the cases now referred to were due to such a cause. I shall, however, notice them only very briefly.

Colonel Hunter also states, that on Saturday the 7th February, the Rev. Mr Morris, at Muthill, eight miles to the north-west of Auchterarder, saw a distant meteor rise in a long parabolic curve, and apparently fall towards the ground; and in a letter which I have since received from the Rev. Albert J. T. Morris, Muthill, he favours me with the following interesting details:—

"As to the meteor which I saw on the evening of the 7th of February, it was about 7.15 P.M., and was visible for about seventeen or eighteen seconds, quite long enough to be very carefully observed. The horizon was especially free from cloud or vapour. The meteor rose from the horizon (in the S.S.W.) perpendicularly for about 28 degrees, it then curved regularly and fell perpendicularly, disappearing at the horizon, a little to the *westward* of due south, so that its whole parabola, if completed, would have been very much elongated as compared with its shorter diameter.

"From the accounts I afterwards saw in the newspapers, showing that it had been visible at so many various and distant points, I calculated (at the time) that it must have been 300 miles to the south of the

centre of Perthshire (in which I am); and that after being ignited in the higher regions of our atmosphere, it was propelled (perhaps by the shock ?) away from our earth for some hundreds of miles, until the force being expended, it fell again, and was lost below my horizon. I had occasionally seen meteors rise and then fall before, but never saw one do so thus unmistakeably.

"I should have said that the light of the meteor was intense, seeming (perhaps by the contrast) greater than that of a full moon, though its apparent body was not a tenth of the size of a full moon."

This meteor was apparently at a considerable height above the earth's surface, as it appears to have been seen at various places distant from one another; and the following note from our Member, the Rev. Walter Wood, published in the "Daily Review," refers probably to the same luminous body, as seen from a point still more to the castward:—

"*Meteor.*—SIR,—On Saturday, 7th February, between six and seven o'clock, having occasion to go into a room the window of which looked out on the sea, I observed a shimmering light upon the water, which caused me to go nearer to the window in order to see from what it proceeded. I then observed a meteor moving from north-west to south-east in a line nearly horizontal, but somewhat dipping downwards. Hardly had I seen it, when it disappeared exactly in the direction in which I knew Arthur's Seat was. The impression which the momentary glance left upon my eye, was that of a broad blue riband once or twice twisted; but probably its colour was intensely white, and only appeared blue by contrast with the slight blush of sunset, which was still in the sky. I should have fancied it was about a mile off, but if it was the same which I have seen noticed by other observers, it must have been at a very great distance indeed.—I am," &c. "W. WOOD.

"ELIE, FIFE, 19*th February* 1863."

Reference is made at the close of this letter to the newspaper notices of a meteor seen at Alyth, in the east of Perthshire, and other places, which was thus noticed in the "Scotsman" of 13th February:—

"The remarkable meteor seen at Alyth on Saturday night, the 7th February, was also observed over a very extensive range of country. It was seen at Dublin, at Sydenham, and other places in England."

This short notice induces another correspondent to write to the newspapers, giving some additional particulars of apparently the same meteor. He says,—

"EDINBURGH, *February* 13, 1863.

"*Meteor.*—SIR,—I see in your paper of to-day a notice of a meteor being seen at Alyth, Dublin, Sydenham, and other parts of England, on

Saturday last. This is the only notice I have observed of it. On Saturday last (the 7th February), a little after 6 P.M., I saw a meteor, the body of which was intensely white, and it emitted red sparks, not like a stream of light from fireworks, but red sparks at intervals of half a second or so, but irregular. Other two individuals I know saw it about six miles west of Edinburgh. To them it appeared to fall about Ravelrigg Hill. To me it appeared to fall between Curriehill House and Newmilns. I was about a mile distant from the other two who saw it. It appeared flying from north-west to south-east, and describing a curve that must inevitably have brought it to the earth's surface in a few seconds, although it was 150 miles distant, which it probably was. It must have come in contact with our globe to the south or east of Edinburgh, and I can hardly think that it is the same meteor seen south of London, unless it was seen there to the north only.—I am," &c.

"AN OBSERVER."

Scotsman of 16th February 1863.

The following week seems also to have been distinguished by the appearance of a meteor, which was observed passing over Edinburgh, in a different direction, however, to the one previously referred to. One of our members, my friend Mr P. A. Dassauville, writes me, that when returning home along Abercromby Place, towards the west, on the evening of Friday the 13th February, about 11.30 P.M., or a quarter to 12 P.M., he was astonished by the appearance of what seemed to be a ball of fire, which rose over the south end of Wemyss Place, and crossed the open space of the Queen Street Gardens diagonally from the south-west, travelling steadily in an apparently almost horizontal line, to the north-east, and disappearing from his view in that direction, over the houses of Abercromby Place. In its passage overhead, he observed it had a tail of considerable apparent length, which was of the same red or flame colour as the body of the meteor; and its elevation did not appear to be very great. His first impression was, that it might be some firework, but he soon observed it was too high in the air to have been sent off in its apparently horizontal course; and there was also this difference from a firework, that the body did not *leave* a trail of light behind it, but the whole seemed to travel together, at a regular speed, towards the north-east. The night was clear and calm, and no sound was heard to accompany its passage overhead; the direction of the wind was not observed, although he believed it must have been westerly.

The Edinburgh newspapers of 17th February, contained the following note copied from the "St Andrews Gazette":—

"St Andrews—Brilliant Meteor.—On Friday night, the 13th February, about a quarter before twelve o'clock, a magnificent meteor passed over the centre of the town, taking a north-easterly direction. It appeared to be in the lower atmosphere, extended about a degree in length, and was visible for about one minute. It was of a brilliant red appearance, with very bright flame-like flashes in front."—*St Andrews Gazette, Feb.* 1863.

This was therefore apparently the same meteor which was observed passing over Edinburgh a short time before, on its course across the Firth of Forth to St Andrews, and the north-east.

For details of luminous meteors I refer the members to the various works on meteorology, and to the valuable Catalogues that have been published, especially that by Mr R. P. Greg, F.G.S., of Manchester, and the Report of the British Association for 1860; I also beg to recommend the members to put on record all appearances of the kind that may come under their observation, so that from the accumulation of numerous facts, meteorologists may at last be able to educe some general laws on this at present dark and mysterious subject.

In conclusion, I may add the following notes of the fall of a fireball which occurred a good many years ago, and were taken down by me from the description of one of the spectators of this curious phenomenon:—

On a Sunday evening in the beginning of October of the year 1825 or 1826, two carpenters, George Easton and Robert Lawrie, were returning from their homes near Melrose, to be ready to commence their work on the following Monday morning, at the building of the new house of Hollylee, a little below Innerleithen, on the banks of the river Tweed. They were walking between eight and nine o'clock in the evening, on the road, up the river side, which here runs nearly east and west, the weather being fresh and calm, but dark, when suddenly the country was lighted up behind them, and looking back they saw a ball of fire, apparently about the size of a bee-hive, which came at a slow rate from the north-east over the hill top on the left of the valley,

and followed down the slope of the hill all the way, until it struck the ground a few yards from the north side of the road, and about fifty yards west of the slate quarry, opposite to Gleddy's Wheel, a well-known salmon pool about two miles down the river Tweed from Hollylee. The light was so brilliant, that all the road was illuminated, and, as Easton expressed it, he could see to pick a pin off the road; and he observed the meteor was most brilliantly reflected on the surface of the river. When the ball struck the ground, to their astonishment it seemed to break, without much, if any noise, into some thirty or forty fragments, which rolled down the bank, on and over the turnpike road, and into the brushwood, and the river bank below. The portions of the fire-ball, Easton stated, were of all sizes, from a foot-ball to a marble; and he considered they might then be about eighty or a hundred yards from the place where it burst and crossed the road. Both he and his comrade were much alarmed, as the fire-ball seemed to be coming directly upon them; and they hurried on their way to Hollylee, without waiting to make any further examination, being thankful for their apparently very narrow escape from being struck down, by such a formidable-looking stranger.

Dr STEVENSON MACADAM said it was interesting to have the story of the supposed fall of an aërolite detailed and investigated, as in the present case. Some years ago the fall of an aerolite in England was fully described in the "Times." It so happened that the person on whose farm it was believed to have fallen, was an acquaintance of the late Dr George Wilson, whose assistant he (Dr Macadam) was at the time. The supposed meteoric stone was picked up and sent to Dr Wilson, and on chemical examination by Dr Macadam, was discovered to be, as in this instance, simply a mass of iron pyrites.

IV. *Remarks on a "Raised Beach" at Ardross, in the County of Fife.* By the Rev. WALTER WOOD, Elie. Communicated by JAMES M'BAIN, M.D., R.N.

A short notice of this raised beach will be found in "The East Neuk of Fife" (p. 323); but the heavy gales of last

winter (1862–3) having exposed a new section of it, I have thought it worth while to set down the results of a fresh examination.

The beach begins a little way east of the railway bridge, at the cottages of the farm of Ardross. There the land rises gradually from the high-water mark; and the bed of shells of which we speak is scarcely at all elevated above high-water, and, by the percolation of water impregnated with iron, has been formed into a kind of rock.

Passing eastward, the same bed may be noticed at various elevations, according to the character and configuration of the shore. Before travelling many steps in that direction, the shore presents a perpendicular escarpment, rising about eight feet above high-water mark. There the bed of shells appears at about the height of six feet. It is not level, but undulating; and it is noticeable that the shells occur most abundantly in the higher portions of the bed, while the lower portions are chiefly occupied with rolled pebbles.

The shells themselves are generally fragments of the *cardium*, *mactra*, *trochus*, *patella*, and *litorina*, with an occasional land-snail shell, and are disposed in no kind of order, and mixed with rolled pebbles.

The cliff on the shore gradually becomes higher, and the shell-bed rises along with it from six feet to nine, and ultimately, on the summit of the rock on which the ruins of Ardross Castle stand, to twelve feet above high-water mark.

It is worthy of remark, that, as the bed rises higher, the number of rolled pebbles diminishes, and their place is supplied by angular and unworn fragments; and at the highest point the latter so far preponderate that scarcely a rolled pebble can be found.

On the whole, the conclusion to be drawn from all these appearances is, that this is no proper example of a raised beach—

1. Because the different heights at which within a few yards it makes its appearance cannot well be accounted for by any supposed elevation of the land.

2. Because the entire absence of rolled pebbles from the higher portions of the bed indicates that these were never,

or at least very seldom, exposed to the direct influence of the sea.

On the question as to how these appearances could have been produced, I still adhere to the opinion which I have already stated in print. In my judgment, the supposition of a long, gradually sloping beach will account for them all. On such a slope, storm-waves would carry shells and other light materials to a height of twelve or even fifteen feet, and the wind would transport them to even a greater elevation. At the point nearest the sea, rolled pebbles would be deposited along with the shells, while at a greater distance only angular fragments would find their place. If, then, this sloping beach were undermined, and gradually eaten away, it would present an escarpment with a bed of shells from six to twelve feet above high-water mark.

I think that on the west shoulder of the rock of Ardross Castle there still remains a small portion of the original sloping bank, which, in a direction towards the sea, falls in a small space at least two feet, showing a shell-bed at every point.

Wednesday, April 22, 1863.—James M'Bain, M.D , R.N., President, in the Chair.

The following Donations to the Library were laid on the table, and thanks voted to the Donors:—

1. (1.) Transactions of the Royal Society of Edinburgh, Vol. XXII., Part. I.,—Session 1861-62; (2.) Proceedings of the Royal Society of Edinburgh, Vol. IV., No. 56, 1861-62.—From the Society. 2. The Canadian Naturalist and Geologist, and Proceedings of the Natural History Society of Montreal, Vol. VII., No 6, December 1862.—From the Society. 3. History and Description of Needle-making, by Abel Morrall, manufacturer, Manchester.—From the Author. 4. (1.) Classification of the Coleoptera of North America, by John L. Leconte, M.D., Part I., 1861-62. (2.) Synopsis of the Neuroptera of North America, by Hermann Hagen, July 1861. (3.) Synopsis of the Lepidoptera of North America; Part I., Diurnal and Crepuscular Lepidoptera, by John G. Morris, Feb. 1862. (4.) Catalogue of Publications of the Smithsonian Institution, corrected to June 1862. (5.) Annual Report of Board of Regents of the Smithsonian Institution, 1860.—From the Smithsonian Institution, U. S. A. 5. Natuurkundig Tijdschrift voor Nederlandsch Indie, deel xxiv, 1862. 6. Transactions of the Royal Scottish Society of Arts, Vol. VI., Part II., 1862.—From the Society. 7. Report of the Royal Commission on the Operation of the Acts re-

lating to Trawling for Herring on the Coasts of Scotland, 1863.—From the Board of Fisheries. 8. Proceedings of the Royal Society (London), Vol XII., Nos. 53, 54.—From the Society.

The usual Committees were appointed for conducting special investigations during the summer.

Mr George Logan made some remarks on the recently published Report of the Royal Commission on our Fisheries, now presented to the Library; and referred especially to the opinions there enunciated as to the herring and sprat fisheries, which exactly corresponded with those always advocated by this Society.

The following Communications were read:—

I. *On the Evidence of the Rise of the Shores of the Firth of Forth* By Alexander Bryson, Esq.

Mr Bryson described various places on the shores of the Firth of Forth, to show that there was not the slightest evidence to be found of any rise of level, at least in recent times. He referred to the rock at Cramond sculptured with the Roman eagle, believed by antiquaries to be the work of the Romans; and showed that it was now just above high-water mark, so that, if a rise of twenty-five feet, as has been assumed, or indeed any rise at all, had taken place since that time, this rock must have been entirely under water at the Roman period. He alluded to the position of the Roman wall at Carriden, and showed that no remains of it had been visible for at least 200 years back; so that no evidence of any kind could be got from it. He also pointed out the existence of an extensive fluviatile or fresh-water deposit, at the mouth of the river Almond at Cramond, without any included marine remains; the existence of which would have been impossible had any great rise of the land taken place here.

II. *Remarks on the Skull of an Ancient Peruvian.* By James M'Bain, M.D., R.N.

The object of the following remarks is to prove the insufficient evidence on which the so-called interparietal bone has been assumed by some authors to be a constant and special peculiarity of the ancient Peruvian race. The skulls which I now exhibit to the Royal Physical Society were presented to me some time ago by Commander George Palmer, formerly first-lieutenant of H.M.S. "Edinburgh."

The skull marked Pachacamac was taken by Commander Palmer from an old Indian " huaca," or burial-place, close to the town of Lurin, seven leagues south of Lima, and not far from the ruins of the old Peruvian temple of Pachacamac—Pachacamac meaning, "He who gives and sustains life," and who was worshipped as the principal deity in Peru before the conquering Incas introduced the worship of the sun. This skull has the characteristics described by Dr J. J. Von Tschudi, the Swiss naturalist, and Signior Rivero, director of the Museum of Lima, as belonging to the so-called extinct race of Aturian Paltas, or Flatheads of South America.

The remains of this race are found in the neighbourhood of Lake Titicaca, in Peru, and in the interior of Brazil; and it appears from the statement of Dr Tschudi and Signior Rivero that the flattened form of crania was not, as most naturalists at first thought, the result of artificial pressure,—a practice now resorted to by many of the North American tribes, as the same configuration was found in a fœtus which they took from the mummy of a pregnant woman found in a cave at Huichay, in Peru.

At the meeting of the British Association held at Plymouth in 1841, Dr Bellamy first brought into notice the existence of a bone at the posterior part of the skull situated between the two parietal bones, and immediately above the occipital. This communication is published in the 10th vol. of the " Annals and Magazine of Natural History." In the "Peruvian Antiquities," by Dr Tschudi and Signior Rivero, translated by Dr Hawks, at page 38 it is thus alluded to:—" In conclusion, it may be proper to notice an osteologic anomaly, very interesting, which is observed in the crania of all the three races, and it is this,—that those of children of tender years, in the first months after their birth, present an interparietal bone (os interparietale) perfectly distinct; a bone which, as its name indicates, will be found placed between the two parietals, and having a form more or less triangular, whose sharpest angle is above, and is bounded by the posterior edges of the parietal bones, while its base attaches itself to the occipital bone by a suture which runs from the angle of union of the temporal with the occipital bone, a

little above the upper semicircular line, to the similar angle on the opposite side. It follows that this interparietal bone occupies precisely that part of the occiput which in the other crania is occupied by the upper portion of the occipital, and which is connected with the parietals by the lambdoidal suture. At four or five months, this bone is regularly united to the occipital, and the union begins at the middle of the suture, and advances by little and little towards both sides; although, even after a year, it is not found completely effected, but in the middle only. A furrow shows the trace of the suture; this furrow is not obliterated even at the most advanced age, and may be easily recognised in the crania of all these races."

In describing the cranium of a youth of the tribe called Chinchas, Dr Tschudi states that the length of the interparietal bone in this individual is four inches at the base, and an inch and ten lines high,—dimensions which sufficiently prove that this formation is not to be confounded with that of the small supernumerary bones called Wormiana, which are uniformly found between the parietals in all human crania, so that this interparietal bone is a true anomaly." He further remarks,—"It is a circumstance worthy of the attention of learned anthropologists, that there is thus found in one section of the human race a perpetual anomalous phenomenon which is wanting in all others, but which is characteristic of the ruminant and carnivorous animals." The skull which I now exhibit belongs to the race designated by Tschudi as the Chinchas, the most noted tribe on the Peruvian coast between the 10th and 14th degrees of south latitude; but the other two tribes into which he has divided the ancient Peruvians, namely, the Huancas who occupied the territory between the Cordilleras and the Andes, and the Aymaraes, who inhabited the Peru-Bolivian plateau, upwards of 12,000 feet above the level of the sea, had also, according to Tschudi, the interparietal bone. He adds,—" Amongst the numerous crania which we had the opportunity to examine in Peru, we have had the means of convincing ourselves that this suture is invariably found either open, or closed in part, or completely united to the

occipital bone, and well indicated by a furrow very clearly marked." If this statement be correct, the tribe whose crania were disinterred about the neighbourhood of Lake Titicaca are not singular in respect to this formation of the skull, as all the ancient Peruvians are said to have possessed it. The statements of Drs Bellamy, Tschudi, and Signior Rivero are thus alluded to by Colonel Hamilton Smith, in his "Natural History of the Human Species," who says,—"If the typical Flatheads were not a distinct species of man, they were, at least, the oldest and first wanderers that reached the American continent;" and adds in a note, that "Recent investigations, conducted by Sir Robert Schomburgk, show the Maopityan, or Frog Indian tribe, at the sources of the Corentyn, to be naturally flatheaded. Dr Lund states that he found some skulls in the interior of Brazil in a fossilised state, corresponding to those discovered near the Lake Titicaca. They were in limestone crevices, and mixed with the bones of different species of extinct animals, "proving," as Colonel H. Smith remarks, "both the remote age when this form of man already existed in America, and the extent of surface it is now known to have occupied."

The skull in my possession appears to have belonged to a young person, the sutures being open and distinct, and only fourteen teeth being present in the upper jaw. The *ossa wormiana* extend in the line of the lambdoidal suture, from an inch above the posterior inferior angle of the parietal bone, and are nearly an inch in breadth. The skull belongs to the brachycephalic type, and is somewhat prognathous. The occipito-frontal diameter is $6\frac{4}{10}$ inches, the interparietal diameter is $5\frac{1}{2}$ inches, and the vertical height, measured from the middle of the sagittal suture interiorly to the anterior edge of the occipital foramen, is about 5 inches. The horizontal circumference of the skull, extending from the glabella along the upper margin of the squamous suture and over the occipital protuberance, is $19\frac{1}{2}$ inches. The skull, without the lower jaw, weighs $21\frac{1}{2}$ ounces; the cranial cavity is capable of containing $36\frac{1}{2}$ ounces of millet seed, the anterior portion $10\frac{1}{2}$ ounces, and the posterior 26 ounces, which is nearly in the ratio of one

to three. It is unnecessary to enter into further details, as the above are sufficient for comparison with other crania. I also exhibit a skull brought from the same locality, near Pachacamac, but destitute of *ossa wormiana*, and in which there is not the slightest trace of a furrow to indicate the remains of a former suture. In contrast to the national flatheaded skull, I produce a skull belonging to the tribe of the Chinooks from Vancouver Island. It is a well-known practice amongst this tribe to flatten the head in infancy; but, as Dr Pickering remarks, "As the children grow up, the cranium tends to resume its natural shape, so that the majority of grown persons hardly manifest the existence of the practice. One effect, however," he adds, "seemed to be permanently distinguishable, in the unusual breadth of the face." Both statements are well borne out in an adult specimen in my possession, likewise brought home by Commander Palmer, the breadth between the malar bones being 5¼ inches. I have thus briefly referred to the authorities and statements upon which the hypothesis of a distinct race of man has been founded, and hitherto pretty generally accepted. The chief osteological characters are the peculiar flattening of the skull and the assertion of the constant presence of an inter-parietal bone, or *os Incæ* as it is termed by Von Tschudi, in compliment to the nation in which the peculiarity is said alone to be found. The question has been ably and successfully investigated by Dr Archibald Smith, whose long residence in Lima afforded him favourable opportunities for that purpose. In a communication entitled "Peruvian Gleanings," published in the Edinburgh New Philosophical Journal for 1860, Dr Smith says, "That in regard to the supposed osteological type of wormian bones in all the crania of the Peruvian Indian race, he found, upon due inquiry at the Medical College at Lima, that neither its deacon nor professors could give him the least information. He then applied to Dr Lorenti, one of the best authorities in Peru on such subjects, who at once assured Dr Smith that Tschudi's statement was utterly untrue. Dr Smith afterwards went to the museum, and saw five native Indian skulls from ancient tombs in which the

sutures were visible, but only one showed signs of a wormian bone at all. The so-called interparietal bone, represented as characteristic of all the skulls of the Peruvian Indian race, is not even traceable in any one of the five skulls in the Lima Museum. A skull from the ruins of Pachacamac, deposited by Dr Smith in the Edinburgh Museum of Natural History in the time of Professor Edward Forbes, "has no such peculiarity; neither have two skulls from the Chinchas, in the possession of Professor Simpson, the osteological character in question, and therefore," adds Dr Smith, "none such can be said to be typical of the Peruvians as a race." Dr Smith says, since writing the above, he had been introduced to Dr Charles Scherza of the Imperial Austrian frigate 'Novara.' Dr Smith directed his attention to Dr Tschudi's statement, and on his return from the ancient temple of Pachacamac, where he excavated skulls from the tombs, he assured Dr Smith that he inspected at least fifty crania, and that none of them presented the characteristic of a supraoccipital or interparietal wormian bone.

He had six fine specimens to speak for the Inca race in Europe.

In reference to certain preliminary inquiries into the present state of our knowledge on craniology and its application to ethnological questions, I had occasion some time ago to make frequent visits to the fine and well-arranged collection of skulls contained in the Edinburgh Phrenological Museum. I then took the opportunity of examining the extent and variety of *ossa wormiana*, as exhibited in the different forms of skull, in that readily accessible and valuable collection. For the present I shall briefly state the result of the examination of the crania from South America contained in the museum. Besides a considerable number of casts, there are twelve skulls marked South American, seven of which present no appearance of *ossa wormiana.* Five of the skulls possess wormian bones more or less developed; but only two, those marked 297 and 301, have the wormian bones situated at the occipital spine in the line of the lambdoidal suture. In the specimen marked 297, the facial bones are awanting. There is a wormian bone about

an inch in height, and the same in breadth, at the occipital spine, and others of a less size in the line of the lambdoidal suture and at the mastoid angle. In the specimen 301, marked Chilian, from Valparaiso, the *os wormianum* at the occipital spine is 2 inches broad and 1 inch in height, and there is great irregularity in the line of the lambdoidal suture. In this skull a remarkable horizontal depression, above the superciliary ridge in front, is observed. Five of the skulls are marked Peruvian, from Huacas, near Lima, and in which no trace of *ossa wormiana* can be seen, thus confirming, in a very conclusive manner, the observations of Dr Archibald Smith. In the month of February last, Dr Smith read an interesting communication on this subject to the Society of Antiquaries of Scotland, entitled "Observations on the Inca and Yunga Nations, their Early Remains, and on Ancient Peruvian Skulls."

He then exhibited six specimens of Peruvian skulls disinterred from ancient burying-grounds, and in only one is there to be found a trace of *ossa wormiana,* nor is there to be seen the slightest appearance of a furrow marking a line of obliteration. The specimens are now preserved in the Museum of the Antiquaries here. It may therefore be considered as satisfactorily established, that ancient Peruvian skulls, although occasionally found with wormian bones of a considerable size in the line of the lambdoidal suture, are more frequently destitute of this peculiarity, and that the existence of a so-called interparietal or supraoccipital wormian bone can in no respect be regarded as a special characteristic of the race.

III. *On the Occurrence of the "Rosy Feather Star"* (Comatula rosacea), *on the Eastern Shores of Scotland, especially on that of Caithness.* By Charles W. Peach, Esq., Wick. Communicated by John Alex. Smith, M.D. (Specimens were Exhibited.)

In the description of the "Rosy Feather Star" at page 16 of the "British Star Fishes" by the late Professor Edward Forbes, he, after mentioning its occurrence in several places in England, Ireland, and Wales, adds, "And on the west coast of Scotland by our distinguished zoologist Pennant.

I have never heard of its being found on the eastern shores, though in Shetland, Mr Goodsir and I found several in ten fathoms on Laminaria." Dr Carpenter, in the Third Edition of "The Microscope," at page 583, in a foot note, states that it is found in Kirkwall Bay, Orkney.

I am happy in saying, that although very rare, it is not altogether wanting on our eastern shores. During my residence at Peterhead (about three and a half years), I met with but one specimen; it was in the stomach of a fish, and although taken from such a situation (as may be seen by the specimen herewith sent), it was not much mutilated.

In his "List of the *Echinodermata* of the Moray Firth," the Rev. George Gordon mentions having met with "a very mutilated specimen from the stomach of a haddock killed in the Moray Firth in 1850."

Although I have looked out for them attentively here more than eight years), two only have come under my notice, one from the stomach of a fish, thus again showing the best star-fish hunters. Last summer I got the other out of a fishing-boat at Staxigo; it was small and living, hooked to a shell. I kept it alive for a long time, and although it waved its arms about when disturbed, I never could perceive that it moved from the spot it was hooked to when I got it. It held on firmly by the claws of the filiform processes with its arms stiffly held up, as well represented by Gosse in his "Manual of Marine Zoology," vol. i., page 63, fig. 93. I had this pretty object so placed that I could examine it with a powerful lens and see its very slow movements. It appeared to be very indolent; it was about an inch from tip to tip of the arms. Unfortunately, in showing it to a friend, my finger slipped, and like most pets, it came to an ill end.

A short time ago I had presented to me by Miss Miller, of High Street, Thurso, a nice specimen of sponge, *Halichondria palmata.* It was taken in 1862, on a fisherman's line in the Pentland Firth; fortunately it was carefully preserved and left unwashed, with all its own juices, and the objects parasitical on it. (The specimen accompanies this paper.) On it is a fine family of Rosy Feather Stars, two

adult and eleven young, in different stages of growth. One of the adult has curled its arms into Ammonite-like forms, the delicate pinnæ being intertwined gracefully with the arms in the most beautiful manner, adding greatly to its loveliness. Both adult and young are moored by the claws of the filiform processes to the meshes of the sponge. The adult are a short distance from each other, and near the top of the sponge; some of the young are sheltered under the arms of one of the old ones, others are scattered singly about the sponge. In another spot, a group of four or five are safely ensconced in a nice nook, low down, where four branches take their rise. All the Rosy Feather Stars are on the inner part of the branches of the sponge, and thus sheltered from injury. A few of the filiform processes and other portions which fell from the Thurso specimens are inclosed in glass for your inspection, where the claws, &c. may be seen.

The filiform processes have, as well as claws on the tips (as figured by Forbes), similar smooth-like processes on the inside of the body of the two next joints, and as well short but stout spines on the upper part of each joint. Shorter spines may be seen on the upper part of the bifurcated arms.

Having now found the habitat and nursery of this hitherto stranger, it is possible we may often hear of it, and in time welcome the "little strangers" whilst attached to their jointed stalks, before being cast adrift in the world of waters on their own account. This fixed state I frequently met with when I lived in Cornwall. I find, on referring to my diary for 1844, that I noticed many so moored on the stones used to sink the "crab-pots," and also on the rods of which the pots were made. At that time such "wee things," and "little wonders" were not so well understood as now. I removed from the sponge, for preservation, several young specimens of *Ophiocoma rosula*, varying in size from a spiny egg about two lines across, to rayed ones more than ¼th of an inch over, and had the pleasure of tracing the hooked spines, &c. mentioned in my previous papers on Star-fishes to your Society.

IV. *The "Kjökken-Möddinger" of Denmark, and their Similitudes on the Elginshire Coast.* By the Rev. George Gordon, LL.D., Minister of Birnie. Communicated by George Logan, Esq., W.S. (Illustrative Specimens of the different Shells were Exhibited.)

Kjökken-Möddinger is a Danish word applied to masses of the remains, chiefly of edible shell-fish, found around the shores of Denmark. When literally given in English it comes to be a well-known and homely term, which is probably not very different in sound from the original. In Denmark these masses have been long known, but were little regarded by the archæologist, and at times spoken of by the geologist as shells left by the sea when the land was more deeply immerged in the ocean than it is at present. Within the last few years it has been ascertained that these collections of shells are the dust-heaps made up of the debris of the food on which the earlier inhabitants of that territory subsisted, and closer examination of their contents has thrown light on the manners and customs of those rude tribes who first settled on the shores of Scandinavia.

Kjökken-Möddinger are by no means rare along our own shores. Several of them have been compared with the description given of those in Denmark, and they are found to agree in many striking particulars. They are most likely to be found all round the British coasts. The object of the present notice is to invite attention to some facts, which, if well worked out by such as have the opportunity, will tend to show how the earlier occupiers of Morayland lived and fared. This end will be best advanced by those who take an interest in the subject making known any locality where shell-heaps have been met with similar to those which are here to be enumerated.

From two papers, one by Mr Lubbock in the "Natural History Review" for October 1861; the other by Mr Norman, published by Macmillan and Company, it appears that the people, of whose means of living these shell-heaps are the vestiges, existed in Denmark in what is known in antiquarian works as the Stone Age, or that earliest period of

civilisation, if it can be so reckoned, in which men knew not the use of metals, and consequently had to form all the implements they employed out of flint or bone. The dust-heaps of Northern Europe are assigned to this most distant era from the presence in and around them of implements formed from such materials, and from the entire absence of anything forged of bronze, or worked out of iron—metals that characterise and give name to the two succeeding periods of antiquity. Mr Lubbock says of the Stone period, that, in Denmark at least, "men seem to have been exclusively hunters and fishermen. With the Bronze Age we find evidences of a pastoral and agricultural life. It is probable that the men of the Stone period were conquered, and partly replaced, by a more civilised race coming from the East. It is not only the introduction of bronze and domestic animals which point to such a conclusion. The new people burned their dead, and collected the bones in funeral urns." In the earlier or Stone period, the bodies of the dead seem not to have been so consumed, "for the tombs of this (the Stone) period are chambers formed by enormous blocks of stone, that it is difficult to imagine how they can have been brought into position. The bodies were placed in a sitting posture, with their backs resting against the stones, and their knees brought up under their chins." This most ancient known period of human life in Northern Europe has been subdivided into two portions of time—the first indicated by the comparative rudeness or roughness of the stone implements; the second, by the fine polish superinduced on them as art advanced. The Kjökken-Möddinger are referred to the second. The remoteness of that period can now only be guessed at.

A very singular clue or illustration has been discovered, and is thus described by the authors referred to. In digging down through the mosses, or peat bogs, of Denmark, four distinct and successive layers have been passed. The lowest, or that lying on the surface of the earth, consists of peaty matter only, and contains nothing showing any trace of art, or of the hand of man. The second ascending layer is full of grown pines (Scots firs), which have flourished

and faded until the soil got sick of them. Among these firs the first indication of humanity is to be met with in the shape of weapons and implements formed out of flint and the harder stones. Along with them there are remains of the capercailzie or cock-of-the-wood. Above this we have the third layer, which is composed of oaks; and in it articles made of bronze first appear. When the oaks exhausted all the pabulum in the soil suited for their support, they seem to have given way to the beech forests, which are, at this date, one of the most striking features of Denmark. Among the beech, or in the highest layer of all, iron instruments occur. Thus, as Mr Lubbock writes, "while one race of men have exterminated another, and has in its turn been supplanted by a third, great changes in the vegetation have also taken place. It is manifestly impossible to affix a date in years to the formation of the Kjökken-Möddinger, which nevertheless are of immense antiquity. We have seen that at the time of the Romans the country was, as now, covered by beech forests, and yet we know that during the Bronze Age beeches were absent, or only represented by a few stragglers, while the whole country was covered by oaks. This change implies a great lapse of time, even if we suppose that but a few generations of oaks succeeded one another. We know also that oaks had been preceded by pines, and that the country was inhabited even then."

On our own sandy shores and gravelly beeches of Elginshire, somewhat inland, and raised above the level of the highest tides, most people in their sea-side saunterings must have come upon masses of whitened and decayed shells, at times several yards in circumference, and some feet in depth. On passing these heaps, the reflection or remark may have arisen that the marine animals had been left to die there by the receding waters, or that, after the death of their inhabitants, the shells had been collected at some early period by an eddy of the ocean. Such oversight, or mistake, may possibly have been committed even by the scientific observer. It would be of importance, therefore, that, after the knowledge that has been got of these Kjökken-Möddinger, some of those localities around the British shores

were re-examined where "shelly deposits," "marine remains," or an "oyster," "cockle," or "mussel-bed," have been adduced as evidence of a raised sea margin, of the newer Pliocene, or of a still more recent deposit. Some of these may perchance now be detected and proved to be the artificial but interesting matters we are here discussing—the works of art, and not of nature. It is certain that some of these heaps within the Province of Moray have been regarded as nothing else than the useless parts of his bait, which have been thrown down, as we now see, beside some fisherman's dwelling, where he and his family, at no very distant age, may have pursued the same line of life as his active descendants now follow in our thriving sea-side villages. But no such origin for these mounds of shells, as these suppositions suggest, will now stand a closer examination than the partial, transient glance given to them by the valetudinarian spending his holiday at Branderburgh, Covesea, Burghead, or Findhorn. They are henceforth to be looked upon as instructive objects for the archæologist, whether visitor or resident; and indeed they must become interesting to all who wish to know aught of the lives and habits of the early inhabitants, it may be of the aborigines of Moray.

The singularly attractive discoveries which have been lately made in Denmark, and the publicity which the savans in that country have given to their discoveries, have been the means of drawing the attention of British observers to this savoury subject; while around the shores of the Moray Firth there are enough of materials to give it a local interest. But in thus associating Denmark with the shores of the Moray Firth, the times of the growth of these shell-heaps must not be assimilated with the invasions or settlements of Northmen in Scotland. Some, at least, of the Kjökken-Möddinger, now seen around the Moray Firth, were things of antiquity long before the prows of the Vikingr passed Kinnaird's Head, or ever Dane put ashore at Tordun, and changed the name of that ancient British stronghold into the Scandinavian one of Brough. There are proofs in the flint arrowheads, flakes, and knives, and in the stone

hammers and axes that have been found throughout our province, that it, like almost every district in the world, had its *stone* or earliest period of civilisation. It is hoped that now some further proof may be adduced by some of these shell-heaps revealing more of those pristine implements. Still, with all the proofs that have been gathered, at home and abroad, the *stone* age can be only relatively fixed. It preceded the *bronze*, as this again preceded the *iron* age.

By far the most striking, if not the most ancient example of the Kjökken-Möddinger we have in our vicinity is that one which lies within a small wood on the old margin of the Loch of Spynie, and on a sort of promontory formed of those raised shingle beaches, so well developed in that quarter. It is on the south side of the road leading from Lossiemouth, and considerably nearer the farm-steading of Brigzes than to that of Oakenhead. It is on the former farm, and on the estate of Kinnedar. It has been much diminished by its contents being carted off from the centre as manure or top-dressings for the adjacent fields. It was but a few days ago that we saw a layer of shells from it thickly laid on a dunghill made up from the strawyard of the farm, preparatory to the coming crop. Ossian, we believe, would look upon this mound, and be reminded of "the tales of days of other years," and of the "feasts" of which he so pathetically sung. But "the sound of shells has ceased;" their "joy" and "generous strength" no more "go round." "On the side of Mora," no Fingalian "heroes gather to the feast." The Dane has given these mounds a name fraught with aught but our wonted associations with the halls of Morven—a name, however, which the husbandman seems to have adopted, and to act upon in the obliterating operations of the present hour. It is hoped that the ample fringe of shells that yet remains on the farm of Brigzes will now be preserved, as the memorial of, truly, auld lang syne.

To this day there exists, among some of our neighbours in the upland districts of the province (descendants of the heroic followers of Fingal), the custom of paying a visit

annually to the seaside, even though it should be but for a few hours, under the impression, unquestionably, that some benefit is thereby derived. The visitors generally return to their homes with some shelly trophy, to adorn their mantlepieces or the sills of the window. Can this custom be the vestiges of the summer migration of an early ancestry? It would be well if this hint were taken up, and information gathered as to the names, seasons, purposes, traditions, &c., of these maritime pilgrimages.

There is enough yet left at Brigzes to enable one to form a pretty correct idea of the size of the mound there on the day on which it was ostracised—forsaken, by the throwing of the last shell. This mound, or rather these two mounds (for there is an intervening portion of the ground that has no shells), must have been of considerable extent. A rough measurement gives eighty by thirty yards for the larger, and twenty-six by thirty for the smaller portion. The most abundant shell is the periwinkle—the edible "buckie," as it is provincially called. Next in order as to frequency, is the oyster, and magnificent "natives" they must have been! No doubt, when this favourite shell-fish was served up at the feasts held on its margin, the bed of the Loch of Spynie, then an arm of the sea, was the productive dredging-ground. On that extensive flat, wherever canal or ditch has been dug, oysters are met with, seemingly on the spots where they lived. The oyster, as well as those who had it as a large item in their bill of fare, has passed away from our coasts. Save in some of the sheltered nooks of our Firth, as at Cromarty, Altirlie, and Avoch, we know not where a small dish of them could be procured. A similar account is given of the disappearance of the oyster from the shores of Denmark, where, as on our own coasts, it was formerly so abundant. As third in order, in this mound, is the muscle, and then the cockle. Each of these species, however, bears but a small proportion to either of the former two. These four—the oyster, cockle, muscle, and periwinkle, have long retained the preference they seem to have so early obtained as food, for they are almost the only species of their class that are now brought for sale to the markets

of Scotland. The limpet, and samples of some more species of shell, are to be picked up. One of them (*Tapes decussata*) claims special notice. Its remains hold the fifth, if not a higher place, in the shell mound at Brigzes. It is not known to exist now in the Moray Firth; and (*upon the best possible* authority on such matters*) the most northerly locality where it is now found alive is the coast of Carnarvonshire. It seems to form a striking exception to the rule. While the other species, that are now extinct on our shores, are withdrawing to the north, and are found alive only towards the Arctic Circle, this species, once frequent, but not now known with us, has withdrawn in the opposite direction —to a warmer latitude.

There is evidence enough in these mounds, and of a like nature as that drawn from the Danish accumulations, to show that they have been the work of man, and not the effect of any tidal current, or of any other natural cause. The shell-fish which these remains represent are, with scarcely an exception, edible, and continue to this day to be eaten. In all deposits by the sea there is abundance of species that have ever been rejected as food. The shells are full-grown or adult shells. In collections made by the sea, the young animals are abundant, and often predominate.

Now, no movements of wind or water could have thus selected the edible and the adult, and left behind the noxious and the young. They must have been gathered by man, and for the purpose of supplying his wants. Many other arguments have been brought forward to prove this, so that there is now no doubt entertained about the matter. One strong proof is, that the oyster and the periwinkle are never found living and mingled together in the same part of the sea. The former exists between tide marks, the other in deep water. The cockle delights in sand; the mussel must be moored to a rock or hard bottom. In different parts of the masses of shells at Brigzes, there are to be seen many stones that have been subjected to considerable heat. They probably have been used in this state for cooking, as is known to be the case among people of primitive habits to

* Robert M'Andrew, Esq., London.

this day. In the local archæological case of the Elgin Museum there are a bronze pin, similar to what is frequently found in Ireland, and two small bits of rude but perforated pottery, which have been picked up from the shells at Brigzes, and which so far indicate a more recent period than that of the Stone Age. It is known that far within the historical period the Bishops of Moray had a seaport near their castle, and that disputes then existed about their fishings at Spynie. Thus, it can only be by a comprehensive collection, and a careful record of such adjuncts as may turn up of bone, stone, bronze, iron, &c., that some idea can be got of the era and continuance of that mode of living which these shell mounds on our shores so strikingly reveal.

About a gunshot to the east of this large mound of shells there is a trench, with its inner corresponding rampart. It looks like one of those ancient earthworks reckoned to have been British forts, such as are not uncommon in this county. Had it ever any other tie or connection with the mound of shells than that of juxtaposition? It is of an oval shape, and measures about seventy by fifty-three yards. There is a current idea that this excavation is of modern date, at least within the historical period; but, notwithstanding all that is said on this point, it is worthy of the inspection of the archæologist, as there is little chance of his digging from it an "A.D.L.L.," or of his meeting near it an Edie Ochiltree to give his mortifying interpretation.

Smaller collections of shells, but of the same sort, are to be seen at different places along the road leading from Brigzes to Lossiemouth—as on the north side of Oakenhead Farm, and also high up on the east side of the canal, where it enters the shingly beach, and is crossed by the bridge.

Another of these ancient shell-heaps on our shores claims special attention, as it contains, along with the usual species of edible shells, a number of bones of animals. It is on the west side of the Burghead Railway, perhaps not a mile from the terminus, as it cuts through the Bennet* hill. Here, as in Denmark, the larger bones have been broken up longitudinally, to get at the marrow; or, as Mr Lubbock says—

* Bonnet, from its shape.—Ed.

" In every case the bones which contain marrow are split open in the manner best adapted for its extraction, and this peculiarity, which has not been observed in bones from the true Tertiary strata, is in itself satisfactory proof of the presence of man." The long tract that stretches from Burghead to the village of Findhorn probably contains several of these shelly heaps; at least, near the last-named place, collections of them appear, in which the mussel is a large element, and which seem to be very different, both as to locality and contents, from those accumulations thrown out by the present race of fishermen. Meft-hill, near Urquhart, and also a spot on the east side of the Findrassie property, have been the sitesof the ancient Kjökken-Möddinger. They are to be seen between Delnies and Fort-George; and if they also occur, as is supposed, in the seaward parts of Culbin sands, it would be interesting to trace the line of demarcation between them and those vestiges of a more recent human occupancy than are frequently to be seen in that now desolate region.

Mr Lubbock states, that " the absence of human remains satisfactorily proves that the primitive population of the North were free from the practice of cannibalism. On the other hand, the tumuli have supplied us with numerous skeletons of this period. The skulls are very round, and in many respects resemble those of the Laps, but have a more projecting ridge over the eye. One curious peculiarity was, that their front teeth did not overlap as ours do, but met one another, as do those of the Greenlanders at the present day. This evidently indicates a peculiar manner of eating. Much (continues Mr Lubbock) as still remains to be made out respecting the men of the Stone period, the facts already ascertained, like a few strokes by a clever draughtsman, supply us with the elements of an outline sketch."

Dr Smith stated in regard to the next paper,—that as the Bronze Implement was the most important of the remains found in the gravel bed, he had recently brought the subject under the notice of the Society of Antiquaries of Scotland, and presented the relic, with the bones, to their

Museum. Some of the members thought, however, that this need form no insurmountable reason why the paper might not also be read to this Society, beds of sand and gravel having of late become of much more interest to all naturalists, from the presence in many of them of early human remains; accordingly he had much pleasure in being allowed to read the following notes:—

V. *Remarks on a Bronze Implement, and Bones of the Ox and Dog, found in a bed of undisturbed gravel at Kinleith, near Currie, Mid-Lothian.* By JOHN ALEX. SMITH, M.D. (The Bones and Bronze Implement were Exhibited.)

Locality.—A little to the east of the village of Currie, and rather more than five miles to the west of Edinburgh, the Water of Leith receives on its right bank the streamlet of the Kinleith Burn, which flows in a rapid though short course from the Pentland Hills immediately to the south. Below the junction of the Kinleith Burn, the narrow valley of the Water of Leith gradually becomes wider, and opens into an oval-shaped haugh of tolerably level land, measuring altogether some 8 or 10 acres; and, at the lower extremity of this valley, where the banks on each side again approach the stream, the bed of the river, as the Ordnance Survey Map informs us, is 400 feet above the level of the sea.

The Water of Leith runs along the northern border of the haugh just referred to; and on the level part of the ground are situated the paper mills of Kinleith, about midway between the stream and the sloping bank, which bounds the valley on the south. The engine chimney rises at the south side of the works, and from its prominent position in the gorge of the little valley, it has on two different occasions been struck and partially injured by lightning; in consequence of which the proprietor, Mr Henry Bruce, determined last summer to build a new chimney, a little to the south and east of the old one. For this purpose, a circular space of ground, about 23 feet in diameter, was marked out on the green turf of the level haugh, at a distance of 293 feet from the present bed of the stream; and the process of excavation commenced. The superficial vegetable mould was first cut through and removed, when finely laminated beds of sand and clay were exposed; in some places the former, in others the latter being most abundant. [Specimens of the pure sand, and clay, were exhibited.]

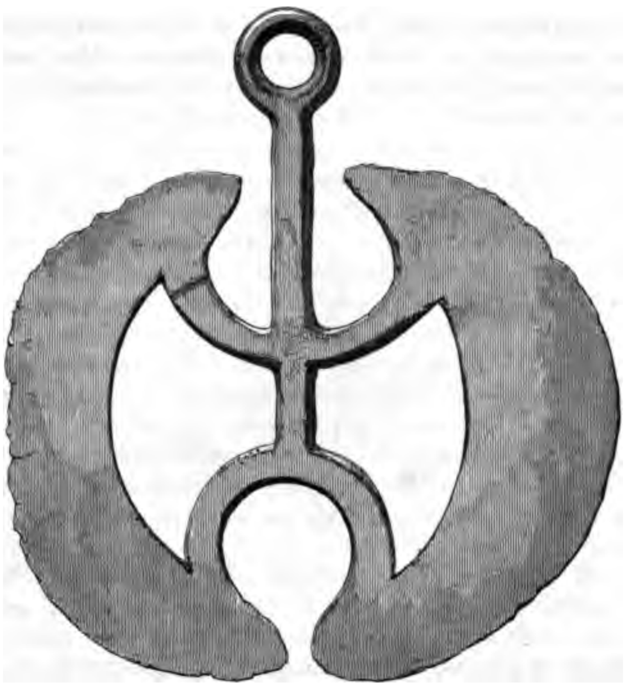
Section of Beds.—These beds of sand and clay measured from 5

feet to 5 feet 8 inches in thickness or depth, and contained comparatively few small pebbles; indeed, on searching the cut sides of the excavation, scarcely one could be detected. Below the sand, however, a bed of rough gravel was reached, consisting of stones of various sizes, from the large boulders of more than a yard across, evidently derived from the neighbouring boulder-clay, to the smaller-sized pebbles of ordinary gravel, little or no sand being intermixed. This bed of gravel measured about 5 feet in thickness, and was found to overlie the solid rock, a stratum of hard limestone being exposed below; the stratum was broken and uneven on its surface, and dipped slightly towards the south, thus causing the bed of gravel to vary in thickness, in different parts, to the extent of nearly a foot. The whole gravel was then gradually cleared away, to allow the foundations of the chimney to be placed on the solid rock. It was when some large stones were being removed from the west side of this gravel bed, about 6 inches or so from the bottom, and nearly 11 feet from the surface of the ground, that the bronze implement (now exhibited) was discovered, on Friday, the 27th of June last. Mr Bruce kindly informed me of its discovery, and I visited the place shortly after, and had pointed out to me the exact spot where it was found. It was lying in the closely-packed gravel, behind several large stones, which lay to the west of it—up the course of the old current or stream.

Bones of Ox and Dog found.—A few broken pieces of bone were also found; and Mr Bruce, at my request, had a strict watch kept, to see if anything else could be discovered, especially any teeth, which, from their hardness and density, are occasionally found well preserved in gravel; only a few more bones, however, were found as the excavation went on, lying in different parts of the gravel-bed, and especially towards the east side of the pit; these were principally fragments, broken probably from their friction in the gravel; and they split and crumbled so much when touched, from their age and absence of their gelatinous constituents, that it was necessary to steep them in glue before they could be handled. These pieces consist of various bones of the ox, part of the left hip-joint or acetabulum, with a portion of the pubic bone attached; lower portions of the tibia or leg-bone, and cannon or metatarsal bone of the same side; and the condyles or lower part of the femur or thigh-bone of the right side. All these bones belonged to an ox of moderate or rather small size. Another bone was, however, picked up, a radius from the right fore-leg of a moderate-sized dog. (The bones were exhibited.)

Bronze Implement found.—The bronze implement found is a very curious one. (See fig. 1, where it is drawn of the full size.) We have nothing like it in our Museum; and I have not been able to find a notice of any similar weapon having been discovered in Britain. It has been formed probably from a plate of bronze, cast in a mould, and afterwards finished with a tool, the edges being

Fig. 1.



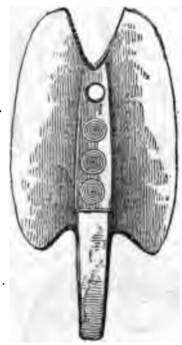
Bronze Implement found at Kinleith, Mid-Lothian. (Scale, size of original.)

thin and sharp, and the thicker central part terminating in a circular loop or ring, which forms a handle, and this handle is further defined by openings left in the central part of the plate, the result being the regular figure which the whole forms, with its two pairs of bent branches passing outwards on each side from the central bar or handle, and each pair supporting a crescentic or semicircular blade, which becomes gradually thinner towards its outer and rounded margin. In cutting out or finishing these

spaces from the centre of the plate, the tool seems to have been used in one direction only, without moving the metal plate, the apertures being all cut from the same side, and the cut surfaces bevelled in the same direction. The metal of which it is composed seems to be very pure and fine. One of the blades, however, has become considerably corroded, the green carbonate of copper having formed over a great part of its surface.

The implement measures $3\frac{3}{4}$ inches in length, the handle being $2\frac{1}{2}$ inches long; each of the blades is $2\frac{7}{8}$ inches in length, by $\frac{3}{4}$ths of an inch across the middle; and the whole measures $3\frac{1}{2}$ inches across, from face to face of the rounded blades. The handle is $\frac{1}{8}$th of an inch in thickness; and the metal is gradually thinned down from the centre, to a fine edge, on each side.

Fig. 2.



Bronze Razor (as supposed), from Museum of Royal Irish Academy, Dublin. (Scale, one-half of size.)

The shape and character of the instrument shows it to have been evidently intended for some cutting purpose, and reminded me at first of a saddler's or shoemaker's knife for cutting leather. The extreme delicacy and thinness of blade, however, would make it quite unfit for any such rough purpose.

Irish Bronze Instrument.—In the Catalogue of the metallic materials in the Museum of the Royal Irish Academy, under the title of Toilet Articles, a figure is given of the largest of three bronze implements, which appear to me to belong to at least the same Class of instruments as this one, though certainly not to exactly the same species or pattern. (See the annexed woodcut, fig. 2, where this Irish bronze is drawn to a scale of one-half its

natural size.) The Irish specimen is described in the Catalogue referred to (p. 549) as follows:—"It is all of one piece, 3¼ inches long, 1¾ wide; has a stout, flat stem, decorated on the surface, with an aperture near the top; and has exceedingly hard, sharp side-edges. The two other specimens are smaller. There is a large specimen in Trinity College Museum." "It is conjectured they were used as razors."

Supposed Use of the Bronze Implement found at Kinleith.—The appearance of the whole of these bronzes, like that of the one now exhibited, is manifestly suggestive of some kind of delicate cutting or scraping process, not improbably the rather important one of shaving! The circular ring at the extremity of the handle of the

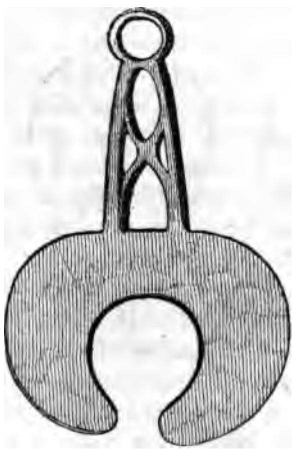
Fig. 8.

Bronze Implement from Kinleith, showing how it may have been held for use. (Scale, one-half of size.)

one found at Kinleith may have been simply for its preservation by suspension, as a valuable and useful instrument, and perhaps ornament; and the Irish ancient "razor" has also a circular opening, pierced, however, at its upper extremity, probably for a similar purpose. It seemed at first rather difficult to account for the peculiar and regular openings cut in the plate of bronze, by which this Kinleith specimen differed in character from the Irish one. I found, however, that by passing my first finger into the rounded opening left between the blades, which indeed it seemed

quite to fit, and my thumb and third finger into the side openings (see sketch, fig. 3, where this instrument is figured to the same scale as the other bronzes, figs. 2 and 4), I could get a complete command of the instrument, for applying its sharp edges to the face, in the supposed act of shaving. It had in this way a steadiness and efficiency not only not possessed by the Irish specimens, but scarcely equalled by our own modern razors. I think it not impossible, therefore, this may have been the way in which it was used; and if the solid and straight double-bladed bronze implements of the Irish Museum were razors; this may probably have been one, and apparently even an improvement on them.

Fig. 4.



Bronze Implement, found in the remains of a Lacustrine Habitation at Steinberg, near Nidau, Switzerland. (Scale, one-half of size.)

Swiss Bronze Implement.—In the valuable work of M. Frederic Troyon, on the "Lacustrine Habitations of Ancient and Modern Times," figures are given of various bronze relics found in Switzerland; and in plate x. fig. 8, there is a drawing of an implement of bronze, which corresponds in character to the one found near Currie, the pattern being but slightly different; inasmuch as a straight and perforated handle, terminating also in an open ring, projects from the rounded side of a single crescent-shaped blade of bronze; the points of the crescent, however, approach one another so closely, that its general resemblance to that found at Kinleith,

is quite apparent (see fig. 4, copied from M. Troyon's work, pl. x. fig. 8; and, like the others, drawn to half its original size). Its size also closely corresponds to the others; the *blades* on each side measuring 2¼ inches, nearly about the same length as the blades of the other bronzes described, and the projecting handle 2¼ inches; its whole length being about 4½ inches, by about 3 inches in breadth measured transversely across the crescentic blades. The Kinleith bronze being 3¼ inches in length by 2⅜ inches across; and each *blade* measuring 2⅞ inches in length; while the Irish bronze measures 3½ inches long, by 1¾ inches across its solid double-edged blade.

I examined M. Troyon's very valuable work, with a special interest, to learn what was his opinion of the supposed use of this blade, or crescent of bronze as he terms it, and found that he gives a very different explanation to the one here suggested, and having nothing whatever to do with the affairs of the toilet! It was discovered, M. Troyon informs us, at Steinberg, near Nidau, which, he says, is one of the most important piled sites on the Lake of Bienne. He describes it as belonging to the age of bronze; and refers it to a class of other crescent-shaped articles of pottery also found there, and considered by him as of particular interest, because that to them, he fancies, some mysterious or supernatural character had been attached.

Swiss Crescents of Pottery and Bronze.—Colonel Schwab, M. Troyon informs us, discovered at Steinberg more than a score of these crescents, formed of a coarse white pottery, ornamented with various lines, and having broken particles of quartz kneaded into the clay of which they were formed. They vary in size, measuring from 8 to 12 (French) inches, from point to point of the horns of the crescent; and at the horns they are from 6 to 8 inches in height. (I exhibit sketches of these articles, copied from M. Troyon's work, which will show their character better than any description.)[1] The lake town of Steinberg, M. Troyon believes, was occupied from a very ancient period; he considers, however, that this symbol of the crescent had not been in use in the very earliest times, or it would have been found in other places along with the most ancient class of remains, which appears not to be the case, as far at least as present discoveries have shown. In 1851, however, at Ebersberg, not far from Berg, in the Canton of Zurich, several fragments of similar crescents, formed of stone, were found along with very ancient remains, M. Troyon, therefore, concludes that

[1] M. Troyon's Habit. Lacust., pl. xvi. p. 184. Lausanne (1860).

the use of the crescent also belonged to the age of bronze. M. Troyon quotes from the Report of our Honorary Member, Dr Ferdinand Keller, in 1858, various explanations of the use or meaning of this religious symbol as he terms it, of the crescent. He supposes these crescent-shaped bodies had no practical use, but were placed either as ornaments on or in their houses, or were used as objects of worship. He refers to the worship of the moon by the Germans, and the use of the crescent and the moon in the worship of the Druids, the moon being considered by them as "that which heals all things." These mysterious healing virtues, which the Gauls also attributed to the moon as the "all healer," sufficiently explain, he thinks, the signification of the images of the crescent discovered at the lake towns of Steinberg and Ebersberg, and he accordingly comes to the conclusion, that these various crescent-shaped bodies had been panaceas, or important healing amulets. Dr Keller also mentions, that Colonel Schwab has in his collection an article of bronze, in the form of a crescent, furnished on its convex side with a projecting handle, being the implement to which I have already referred, and figured; it is described as being very thin or slender, and incapable of resisting much pressure. Dr Keller says, it would be difficult to say whether it has served for a cutting instrument; but it may, like the figures in pottery, &c., of the crescent, have been employed as a sort of amulet, or as an instrument of healing.[1]

After the references by these learned authorities to the mysterious symbol of the crescent, it may seem rather presumptuous in me, who have only seen the drawings, and read the descriptions of these peculiar crescent-shaped pieces of pottery and stone, to suggest at least the possibility of their having had a more practical use. From the great resemblance in the character of the coarse pottery of which they are formed, with its *imbedded fragments of quartz*, to the same arrangement—of broken pieces of quartz imbedded in the clay of which the Roman mortaria were formed—manifestly to increase their grinding power; as shown, indeed, in some of the portions of Roman mortars, presented by me to the Museum, which were found at Newstead, Roxburghshire. I am much inclined to assume, that these crescent-shaped bodies, may have been simply rubbers, pestles, or grinding instruments, to be used by one or both hands according to their size, with or without a mortarium, for crushing or rubbing down the various grains, or harder articles of human food, which, from the remains found in

[1] M. Troyon's Habit. Lacust., p. 188.

these lake dwellings, are known to have been in use at the period of their occupation by man. The short projecting horns of the crescents, would assist in giving a more fixed, or firmer hold to the hands, while using them in the act of trituration or grinding.[1]

However this may have been, there seems to me at least, little doubt, that the bronze crescent, from its great resemblance in character to the implement found at Kinleith, and also those found in Ireland, might have had a practical use, and may be simply a variety in the pattern of this ancient form of bronze knife or razor. The hollow between the horns of this Swiss crescent, where the metal appears to be thicker, and not thinned down to a fine edge, as it is on its *outer* margins, might, by the finger being occasionally hooked over it, also assist in steadying the blade, held by its projecting handle between the other fingers; and in this way it would somewhat correspond to the one found near Currie.

Before concluding, I shall make a few remarks on the supposed *Age of this instrument of bronze.*—Shortly after its discovery, various antiquarian and geological friends, Mr John Stuart, Dr M'Bain, Mr Alexander Bryson, Mr William Turner, and others, went with me, at different times, and made careful examinations of the excavation, as the process of digging went on, and especial attention was paid to the beds cut through above the gravel; there was not the slightest appearance of any pit or digging of any kind having ever been previously made, the beds of sand being quite undisturbed since their first deposition. My friends all agreed with me in thinking there was also no indication of any of the depth of these beds of sand being due to a landslip from the distant sloping banks at the sides of the valley, or any sudden occurrence of that kind. The upper beds being uniform in character, and comparatively free from stones, and so different from the rough gravel below; they were suggestive simply of a gradual deposit of silt from a nearly still pool or lake.

The geologic history of the site being, apparently, that the bed of rough, clean, and large gravel at the bottom, proved the previous existence of the stream of a rapid river, over which man may have

[1] In a letter with which I have since been favoured by Mr Albert Way, he states, that from his own examination of the Swiss crescents of clay and stone, he does not consider them adapted for any purpose of trituration, as suggested by me, and he agrees with Dr Keller in the conjecture of their having borne some relation to the religion, or worship, in these old lake homesteads; Mr Way does not believe, however, in there being any connection between them and the crescent-shaped implement of bronze.

steered his rude canoe, and dropt his bronze knife in the stream; or if you connect together the whole relics found in the same portion of the bed, that of man who had dwelt on the river banks at that early time, when the stream ran over this ancient channel, with cattle, and his dog, in pursuit of which he may have waded in the rough bed of the river. You have next a sudden stop put to the rapid current of the river, at the lower extremity of this valley, probably by an extensive landslip, following long-continued rains, or winter's frost and snow, which might easily have occurred, there, from the right bank on the south, a little farther down the stream, where the steep bank still exposes its broken strata of shales and limestones, all sloping down towards the river bed. The result of this supposed landslip would be the formation in the Kinleith valley of a large still pool or lake, from which the gradual deposit of silt and sand would take place, as it has done to a depth of nearly five feet. The river, however, would at last cut through the barriers by which it had been for some considerable time pent up; but its course has now been somewhat changed; for, instead of spreading over the valley, or running, as it may have done, towards its southern side, the river now finds its way along the northern margin, partly directed, it may have been, by the freshets of the Kinleith burn bringing down abundance of *debris* from its deeply-cut bed, which, becoming arranged principally along the right or south bank of the Water of Leith, especially at the upper end of the valley, would assist in forming the present haugh, and turning the stream towards the northern side of the valley, to occupy its present bed.

Mr Bruce, at my desire, compared the level of the strata exposed at the bottom of this excavation, with that of the same strata in the bed of the stream immediately to the north of his works; in both places the strata were irregularly broken up in a similar manner, and there seemed not much difference between them, the old bed in the excavation being perhaps about a foot or so above the present bed of the river. Over the old river-course, with its accumulation of gravel, a bed of sand had next been formed, to a depth altogether of 11 or 12 feet, and the river had apparently never again returned to its older bed, the *debris* over which now forms a continuous bank, sloping down to its present channel, at a distance of 293 feet from this excavation. The absence of any upper or secondary beds of gravel among the sand and silt of the excavation, shows that the river had never returned to this

spot, as these would necessarily have been formed here, had it ever again, in full stream, flowed over its ancient bed.

This district of country, we know, was the abode of man at a very early period; for, passing by our historical records of its ancient occupation as comparatively recent, the short stone cists or graves of its early inhabitants have been discovered in the immediate vicinity; and in our Museum we have the well-formed skull and ornamented clay urn or drinking-cup taken from a grave of this early character at Juniper Green, on the opposite side of the river. Mr Bruce also informed me that various short cists of a similar character, the stone slabs of which I saw, were exposed when his water-supply ponds were being made, on the slope of the south bank towards the upper extremity of this little valley, immediately above and overlooking this old river bed; and it is to this rather indefinite, but undoubtedly early period, or to one not much later, I am inclined to consider this implement or razor of bronze to have belonged. Similar interments in these short cists have been discovered over an extended range of our country, from the northern counties of Scotland, even towards the south of England, showing, apparently, in this respect, a close resemblance in the customs of these early inhabitants. And from historic record we learn, that at least about half a century before the Christian era, the fashion of partial shaving of the person prevailed in Britain, as Cæsar, in the fourth chapter of his second book "De Bello Gallico," informs us—"the Britons shaved the whole body, with the exception of the head and the upper lip," so that razors of some kind must have been generally used, at that early period.

It is interesting to notice the analogy in character with the bronze implement found in Switzerland, of this one, found among the undisturbed gravel, with its overlying beds of silt, in the valley of a Scottish river, some 400 feet above the level of the sea, implying, no doubt, changes in the district which, as well as the type of the weapon itself, all speak of a great antiquity. We can at present glean but little information as to the exact period of the early occupation of the piled lake dwellings of Switzerland; there seems no reason, however, to assume anything like what may be called geologic periods of time, as necessary to account for the antiquity of their remains. Antiquaries, arranging the various relics found, speak of them as belonging to the so-called ages of stone, of bronze, or of iron; but we know comparatively little importance can be assigned to any such artificial and merely assumed periods of unmeasured time, and we find in our own country various kinds

[illegible] the result of his [illegible]

[illegible] character still exist in [illegible] with much [illegible] dwellings [illegible] that have been found in Western Europe.

Chemical Analysis of the Bronze Implement found at Kinleith.—Having [illegible] analysis of an ancient bronze [illegible] already given in our Proceedings, I placed the bronze implement found at Kinleith in the hands of our well-known practical chemist and lecturer in chemistry Dr Stevenson Macadam, asking him at the same time if he could give me any information of the cause of the different appearance and colour of the green patina which was shown in bronzes of different ages; whether the particular appearance of the patina might give any information as to differences in their composition, and perhaps,

[1] Life and Travels of Herodotus by J. T. Wheeler, vol. i. p. 359, 1855; and Rawlinson's Herodotus, vol. iii. p. 227, 1859.

[2] Nat. Hist. Review, vol. ii. p. 486, 1862.

[3] Proc. Ant. Scot., vol. iv. p. 600.

therefore, of their antiquity. I also wished information as to the hardness of the metal of which this instrument was composed, and its capability of having once had a fine and sharp edge.

Dr Macadam filed a portion of the metal from the back of the straight stalk or handle, where it has since unfortunately been broken; and has kindly favoured me with the following notes, giving the result of his examination :—

"I have examined the bronze implement found at Kinleith, near Currie, and find its composition to be :—

Copper (with trace of lead), . .	92·97
Tin, ...	7·03
	100·00

It is therefore a true bronze, with less than the average proportion of tin.

"The metal was *hard* under the file, and it might have had an edge when new. I have no doubt the rust is a double carbonate and oxide of copper, but I do not know if we can connect the characteristic appearance of this rust with any peculiarity in the composition of the alloy. I would be more inclined to consider that the circumstances in which the implement was placed in regard to moisture and atmospheric action, would play an important part in the formation of the various coloured tints."

This being the concluding meeting of the Session, votes of thanks were given to the Office-bearers, and the Society adjourned to the commencement of next winter session.

of exactly similar remains, in such frequently occurring relations to one another, as leaves little doubt of many of them having been contemporaneous in their use; metallic substances being of course rarer and more valuable in those early days, as well as more perishable, and necessitating in most localities at the same time, the frequent use of the more common articles of stone and bone. The piled sites in this country appear, however, to have been in use down even to a comparatively very recent period, and our Vice-President, Mr Joseph Robertson, considers, as the result of his inquiries, that some of them had been occupied even in mediæval times.

We are told that habitations of a similar character still exist in some parts of the world, as among the Papoos of New Guinea; and historical record tells us of their existence at least as far back as the fifth century before Christ. Herodotus, in chap. 16 and lib. v. of his Life,[1] states that when at the port of Eion on the river Strymon, in Thrace (B.C. 459), he paid a visit to a people who lived in houses built on piled platforms in the lake of Praseas—the Strymonic Lake—according to Colonel Leake the *Takhimos* of the present day. This site has, it seems, been lately rediscovered by M. Delville,[2] and antiquaries, I am sure, will wait with much interest for a careful examination of these ancient lake dwellings with their buried remains, for comparison with those of the Swiss lakes; we would then be better able to judge whether, or how much, it might be necessary to add to an antiquity like this, of nearly 500 years before Christ, when attempting to calculate the age of the corresponding remains that have been found in Western Europe.

Chemical Analysis of the Bronze Implement found at Kinleith.—Being anxious to add another analysis of an ancient bronze to those already given in our Proceedings,[3] I placed the bronze implement, found at Kinleith, in the hands of our well-known practical chemist and lecturer on chemistry, Dr Stevenson Macadam, asking him, at the same time, if he could give me any information of the cause of the different appearance and colour of the ærugo or patina which was shown on bronzes of different ages; whether the particular appearance of the patina might give any information as to differences in their composition, and perhaps,

[1] Life and Travels of Herodotus by J. T. Wheeler, vol. i. p. 359, 1855; and Rawlinson's Herodotus, vol. iii. p. 227, 1859.

[2] Nat. Hist. Review, vol. ii. p. 486, 1862.

[3] Proc. Ant. Scot., vol. iv. p. 600.

therefore, of their antiquity. I also wished information as to the hardness of the metal of which this instrument was composed, and its capability of having once had a fine and sharp edge.

Dr Macadam filed a portion of the metal from the back of the straight stalk or handle, where it has since unfortunately been broken; and has kindly favoured me with the following notes, giving the result of his examination :—

"I have examined the bronze implement found at Kinleith, near Currie, and find its composition to be :—

Copper (with trace of lead), . .	92·97
Tin, ...	7·03
	100·00

It is therefore a true bronze, with less than the average proportion of tin.

"The metal was *hard* under the file, and it might have had an edge when new. I have no doubt the rust is a double carbonate and oxide of copper, but I do not know if we can connect the characteristic appearance of this rust with any peculiarity in the composition of the alloy. I would be more inclined to consider that the circumstances in which the implement was placed in regard to moisture and atmospheric action, would play an important part in the formation of the various coloured tints."

This being the concluding meeting of the Session, votes of thanks were given to the Office-bearers, and the Society adjourned to the commencement of next winter session.

PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

NINETY-THIRD SESSION, 1863-64.

Wednesday, 25th November 1863.—James M'Bain, M.D., R.N., President, in the Chair.

The following Gentlemen were elected Members of the Society :—

As Resident Member—B. H. Hossack, Esq., Star Bank, Trinity. As Non-Resident Members—George Lyle Galbraith, Esq., Loch Tummel Lodge, Pitlochrie; George Fair, M.D., Woodlands, Duddingston; Herbert Manson Suft, Esq., H.M. Privy Council Office, Whitehall.

The following Donations to the Library were laid on the Table, and thanks were voted to the Donors :—

1. (1.) Annual Report of the Smithsonian Institution for 1861, 8vo. From the Smithsonian Institution, U.S.A. (2.) Report of Lieutenant-Colonel J. D. Graham, U.S. Topographical Engineers, on Mason and Dickson's Line.—From the Author. 2. Proceedings of the Royal Society, Vol. XII., Nos. 55 and 56, 1863.—From the Society. 3. Extracts from Twelfth Volume of Astronomical Observations, 1855-59.—From the Royal Observatory, Edinburgh.

Dr M'Bain then delivered the following Opening Address :—

Gentlemen,—Before laying aside the honour you have been pleased to confer upon me, it falls to my lot, as retiring President, to offer a brief address on the occasion.

In the first place, I have to congratulate the members upon the satisfactory state of the Society in regard to the more essential elements of present stability and future progress—namely, a goodly array of scientific contributors, the constant accession of new members, and a respectable balance at the command of the Treasurer. The number of contributions brought forward during last Session on the various

branches of physical science which it is our privilege to study amount to upwards of twenty. Six new members have joined the Society—a fact which, taken along with the important one connected with the funds, may be justly deemed pleasing and conclusive proofs of prosperity. But much of the success of societies like ours depends upon the active exertion of the office-bearers, as well as upon the nature and character of the communications. The valuable services rendered to the Society by the zeal and unremitting attention of our excellent and indefatigable Secretary, and no less careful and attentive Treasurer, are deserving of the highest praise, and merit the unanimous approbation and thanks of the members. The papers read during last Session contain original facts and observations bearing on several highly interesting scientific questions, that cannot fail to support the former reputation of the Society, and to confer additional lustre upon it. There is first a communication on physical geography by Mr Robert Brown, giving an analysis of the discoveries made on the east coast of Greenland, bearing on the site of the eastern and western settlements of early Scandinavian colonies, and on the connection of Scoresby's Sound and Jacob's Bight, with a proposal and plan for a renewed exploration. This active and enterprising naturalist is at present employed as botanist to the British Columbia Expedition, and should the expedition prove successful, and Providence permit of his safe return, much new and valuable information may be anticipated from his well-known zeal, cultivated habits of observation, and devoted attachment to the pursuits of natural science. We had several interesting and suggestive papers on geology and mineralogy, including two by Mr Andrew Taylor—the first, "On the Bituminous Shales of Linlithgowshire and Edinburghshire," and the second, "Remarks on Mineralogical Classification;" Mr Charles Peach "On the Fossils of the Boulder-Clay of Caithness;" the Rev. Walter Wood's "Remarks on a Raised Sea-beach at Ardross, in the county of Fife;" Mr Alex. Bryson "On the Evidence of the Rise of the Shores of the Firth of Forth:" and to these may be added Dr John Alex. Smith's "Note of a Fireball or Aerolite," recently observed

near Auchterarder; the supposed meteorite having been sent to him, after a chemical analysis made by our distinguished member, Dr Murray Thomson, proved to be a mass of bisulphide of iron, accompanying common coal, and in no way connected with meteoric phenomena. In physiology and zoology, excellent papers have also been produced. Mr Edwards "On Torn-off Digits in Man, with reference to analogous injuries in the Lower Animals," and his ingenious and instructive "Notes on some Surgical Homologies;" Professor MacDonald's able and learned exposition "On the Osteological Homology of the Vertebrate Cranium;" and "Remarks on a Peruvian Skull," by Dr James M'Bain. Dr Thomas Strethill Wright continues his brilliant and original "Observations on British Zoophytes," which have already stamped him as one of the best and most accurate observers of the present day. Other zoological papers by Dr John A. Smith, Mr Wm. Ramsay M'Nab, Mr Chas. Peach, and Mr George Logan, are also worthy of commendation. This, it will be confessed, is a goodly amount of work done during the past Session, both in extent and variety, and is at once an index of the vigour that now animates the Society, and a good security for continued progress.

In the midst of our congratulations we are admonished by the solemn warning that death has again entered our ranks, and snatched from amongst us one of our best and most eminent members. Since last meeting the Society has to deplore the loss of Dr John Coldstream, who, had he lived, would have occupied the chair as Senior President during this Session—an office which he formerly held with credit to himself and advantage to the Society. It would be difficult to over-estimate the worth and excellence of character of this most amiable and estimable man. His intimate friends were not more struck with his modest unassuming manner, than by the wide and varied range of scientific knowledge he possessed. And it soon became evident to those less familiar with him, that this information had been acquired by diligent personal observation made on the animals and plants that inhabit our marine shores, as well as by carefully conducted experimental researches performed in the labora-

tory. He was endowed by nature with that rare and fine intellectual capacity where the reasoning and moral faculties are equally balanced, the one, as it were, becoming the counterpoise of the other; hence his whole life has been actively employed in devising means to ameliorate suffering, to extend civilisation by Christian philanthropy, and to promote the universal welfare of society. John Coldstream was born and brought up in Leith, and, after having completed his school education, he was apprenticed to Dr Charles Anderson, an eminent physician in that town, and one of the earlier members of the Wernerian Society. Having finished his apprenticeship, he became an alumnus of the University of Edinburgh, and obtained his degree as doctor in medicine in 1827, his thesis being "*De indole Morborum periodica.*" Shortly after this, we find Dr Coldstream engaged in the pursuit of natural history at Torquay, in Devonshire, where he had gone for the benefit of his health, which appears about this time to have been somewhat impaired. He afterwards took up his residence in Leith, where his professional skill and gentlemanly deportment soon acquired for him an extensive practice, which he retained even after his removal to a wider field in Edinburgh. His health began to give way upwards of a year ago, and for some months previous to his death he was obliged to give up his professional avocations. In the autumn he went to Cumberland, and seems to have so far benefited by the change as to be able to take a journey to Newcastle at the time when the British Association met there. He died, however, somewhat suddenly, a few days afterwards, at Gilsland, in Cumberland, on the 17th September, in his 58th year. Dr John Coldstream early distinguished himself as a successful cultivator of science, by his researches in meteorology and zoology, and more especially by his masterly essays on chromophorous globules of the Cephalopoda, and on *Limnoria terebrans.* He was elected a member of the Royal Physical Society on the 11th of February 1849, having been proposed by Professor Fleming. On the 10th of May 1849, he read a paper "On the Respiratory Currents in the Acephalous *Mollusca*, with general remarks on the mechanism of Respir-

ation in the class." Dr Coldstream was elected one of the Presidents of this Society on the 7th of January 1852, and delivered the opening address on the 23d November 1853. His valuable contributions to zoophytology are recorded and gracefully acknowledged by Dr George Johnston in his classic work on the "History of British Zoophytes," and this gave rise to a frequent correspondence and a lasting friendship between these two congenial and excellent men. Dr Coldstream contributed several articles to the "Cyclopedia of Anatomy and Physiology"—on the Acalephæ, on the Cirrhopoda, on Electricity, and on Luminousness or Animal Phosphorescence. These papers are alike characterised by extensive and accurate information on the subjects treated of, by a fair and impartial criticism of the labours of other writers, and by much original observation. Had it been our purpose to attempt a full biography of this eminent physician, earnest philanthropist, and distinguished savant, many other papers of great value published by him in various periodicals might be added to this list. His biography, indeed, might be summed up in a sentence—He was continually doing good. I trust this brief notice will suffice to show that Dr John Coldstream deserves to rank with those honoured names belonging to this Society, who like Forbes, Miller, Fleming, and many other great men, have by their scientific labours increased the common stock of knowledge, and by their lives have upheld the dignity of human nature.

It has been customary for some time past with my predecessors in the opening address to confine their remarks, in a great measure, to some particular department of natural history which they have themselves made a special object of study. I shall deviate somewhat from this excellent practice, and also from another one, which, indeed, is almost a fundamental principle with our Society—namely, to observe and record facts, rather than to indulge in theory and speculation. Accordingly, I will, on this occasion, occupy a portion of the time at my command in tracing the origin, and in recapitulating some of the facts and arguments that have been adduced in support of—

THE THEORY OF A CENTRAL HEAT, OR OF A HIGH TEMPERATURE IN THE INTERIOR OF THE EARTH. The hypothesis of a central heat is of ancient origin, and more or less connected with the traditions of almost all nations. It assumes that there exists within the earth a vast mass of incandescent fluid matter, the crust of which forms the habitable part of our planet, and this hypothesis has played a prominent part in many schemes of world-making that have long since been forgotten. At the close of the last and beginning of the present century, two rival schools of geology sprung up under the names of Wernerian and Huttonian. The founder of the first was the justly-celebrated German philosopher, Werner, belonging to the University of Freiberg. His leading doctrine was "that the order of position which rocks maintain with respect to the centre of the earth denotes the order of their formation, and that the present arrangement of the rocky strata had been chiefly effected by the action of water—the crystallising process being afterwards induced by certain chemical affinities and molecular changes amongst the particles of which they are composed." With Werner, geology as a science may be said to have commenced—that is, as a science founded upon observation and experiment derived from a careful examination of the structure, contents, and stratigraphical position of the rocks themselves. The second school originated with Dr James Hutton, born in Edinburgh in 1726, and may be termed the Edinburgh school of geology. His well-known work on the "Theory of the Earth" was published in 1795, the preparation of which is said to have occupied his attention for a period of more than thirty years. The Huttonian theory may be divided into two branches or series of suppositions not necessarily dependent upon each other. One branch of the theory assumes that the strata constituting the crust of the earth are, from the nature of their mineral structure and the constant operation of the agents to which they are exposed, liable to decay; and that, by being worn down and transported to the sea, they furnish materials for new strata to be formed and afterwards elevated; and that from the

degredation of a former world the present strata have originated. The second principle assumed in the Huttonian theory is that the materials which are collected at the bottom of the ocean are at great depths exposed to the action of an intense heat, under very strong pressure, by which they are fused and consolidated, so as to be capable of forming new strata. The theory of Hutton was adopted by Playfair, Hall, and others, in opposition to the Wernerian views, at that time also vigorously upheld and taught by Professor Jameson, formerly a pupil of the celebrated philosopher of Freiberg; and, indeed, the intellectual contest carried on between the supporters of the rival systems is a matter of history. In the Huttonian theory the old hypothesis of a central heat became allied to the science of geology, and was for a time a favourite theory with many of our best writers, and used with great freedom, if not license, by some practical and professional geologists. The chief facts on which the speculation is based are the following:—

1st, The existence of volcanoes.

2d, Earthquake phenomena.

3d, Rocks of igneous formation.

4th, Thermal springs.

5th, The increase of temperature in mines in proportion to their depth, and also in water in relation to the depth of the strata from which it flows; and,

6th, The configuration of the earth.

I. *The Existence of Volcanoes.*—The argument derived from volcanoes in favour of a central heat rests mainly upon the fact of the universal spread of volcanic activity over the whole surface of the globe. They exist amongst the snows of the Arctic regions and amongst the islands of the Southern Ocean; in the south of Europe; in Central Asia, South America, the West Indies, and over the whole islands of the Indian Sea. Hence it is inferred that this general distribution of volcanic action is more likely to depend upon one common cause, than to have its origin in a number of local and detached causes. It is evident, however, that the

whole aggregate effect of volcanoes, when compared with the supposed vast magnitude of a central heat, sinks into perfect insignificance.

II. *Earthquake Phenomena.*—The phenomena of earthquakes appear to have an intimate connection with those of subterranean causes, whatever they may be, from which volcanoes originate, so that it is scarcely possible to separate the two actions from an identity of cause. Although earthquakes are found to occur most frequently in volcanic countries, they occasionally happen in localities not subject to volcanic action, and in this case it has been generally observed that the shocks had a greater intensity. It has also been noticed that the most severe shocks are usually of shortest duration. The terrific earthquake which occurred at Lisbon on the 1st November 1755, lasted only six minutes, and in that brief space of time occasioned the destruction of 60,000 persons. The line of devastation extended from Lisbon north to Oporto and south to the bay of Cadiz, a distance of 300 miles. The area of concussion formed an immense ellipse, the longest diameter of which extended from Abo in Finland south to the Canary Islands, a linear space of 2700 miles. The area of vibration through which the waters were observed to oscillate from the shock, included a superficies four times that of Europe, affecting the lakes in Scotland, those in the north of Germany, the springs in Hungary, the Atlantic Ocean across to the West Indies, and even some of the lakes in Canada. Three movements have been observed to take place during an earthquake—a vertical, a horizontal, and a rotatory. The vertical and horizontal often appear to take place together; the rotatory movement is the least frequent, but always the most dangerous. The horizontal movements are propagated in undulations like waves in the sea. They accompany every great earthquake, and travel at the rate of 20 to 30 miles a minute. The three movements were remarkably illustrated by the tremendous earthquake which destroyed the town of Riobamba, in the province of Quito, in South America, on *February* 4, 1797, whereby 40,000 inhabitants perished.

The vertical movement, similar to that of a mine, threw the bodies of many of the inhabitants to a height of several hundred feet on to the hill of La Cullca. By the rotatory movement, walls were changed in their direction without being overthrown; straight and parallel rows of trees were inflected; and in fields having two sorts of cultivation, one crop even took the place before occupied by the other; this last phenomenon showing either a movement of translation, or a mutual penetration of different portions of the ground. Baron Humboldt, to whom we are indebted for this interesting narrative, states that when making a plan of the ruined city of Riobamba, he was shown a place where the whole furniture of one house had been found under the remains of another; the earth had evidently moved like a fluid in streams, of which we must assume that the direction was first downwards, then horizontal, and lastly again upwards. Humboldt distinctly ascertained that this great earthquake was unaccompanied by any noise; the great subterranean detonation which was heard at the cities of Quito and Ibarra—but not at Tacunga and Hambato, which were nearer the centre of movement—occurred eighteen or twenty minutes after the catastrophe. It is but right to state that Mr Mallet, in his Report to the British Association on Earthquake Phenomena, maintains that there is no direct evidence from any observed facts for assuming any vorticose motion of the shock of an earthquake, or any other than a rectilinear one. According to Mallet, Humboldt has fallen into the greater error of mistaking the secondary effects of landslips, and their twistings of the land, for those of vorticose motion. —*Rep. Brit. Assoc.*, 1850. Mallet ascribes the immediate impulses producing earth-waves of shock to—

1*st*, The sudden formation of steam from water previously in a state of repulsion from the heating surfaces (known as the spheroidal state), and which may or may not be again suddenly condensed under pressure of sea-water;

2*d*, To the evolution of steam through fissures, and its irregular and *per saltum* condensation under pressure of sea-water;

3*d*, To great fractures and dislocations in the rocky crust,

suddenly produced by pressure acting on it from beneath, or in any other direction;

4th, Occasionally, but rarely, to the recoil from mighty explosive effects at volcanic foci, as when a mass of rock weighing 200 tons was shot from the crater of Cotopaxi to the distance of nine miles, or when nearly one-half of the crater of Vesuvius was blown away. Earthquake phenomena are therefore considered to furnish very strong arguments in favour of a central heat.

III. *Rocks of Igneous Formation.*—The argument derived from the structure of the igneous class of rocks assumes that the felstone and greenstone series came up from below the stratified rocks at a period long after these were deposited; and as they bear marks of having ascended in a state of fusion, or nearly so, they afford direct evidence, as it were, that there is a very high temperature beneath the crust of the earth, and that melted rock has been in existence at no great depth below the earth's surface, long after it had become the habitation of organised beings.

IV. *Hot Springs.*—The argument derived from the existence of thermal springs is likewise considered to possess considerable weight. Hot springs are found in many parts of the world, at a temperature varying from a few degrees above the mean temperature of the climate up to the boiling point. Those springs possessing the highest temperature generally occur in the vicinity of volcanoes, such as the well-known Geysers in Iceland, and may therefore be attributed to the operation of the same causes which produce volcanic activity. There are other springs, however, scattered over the world at a distance from volcanoes, the high temperature of which it is difficult to account for by any known chemical cause. Humboldt relates an interesting example of common river-water sinking to a great depth, and again reappearing at the surface in the form of hot springs. In September 1759, Jorullo, in the plain of Mexico, was suddenly elevated by volcanic action to a height of 1682 feet above the surrounding plain. Two

small streams disappeared and afterwards burst out afresh during the shock from an earthquake, forming springs whose temperature in 1803 was 158° Fahr. It is worthy of remark that in 1832 Mr Bullock found the heat of these springs to be only a little above the temperature of the climate. The hottest springs in South America were found by Humboldt to contain the smallest amount of mineral matters in solution. Their temperature, however, would appear to be less constant than those of Europe, with a temperature ranging from 122° to 165° Fahr., which have undergone no change during the present century—that is to say, since the application of scientific research by means of the thermometer and by chemical analysis; whereas Humboldt found those of Las Trincheras to increase 12° in twenty-three years. Hot springs, then, show that a heating cause does exist deep in the earth's crust; and their wide distribution tends to prove the wide distribution of that cause, whatever it may be.

V. *The Increase of Temperature in Mines in proportion to their Depth, and in the Water flowing from Borings made for Artesian Wells.*—This argument is of modern date, and has a much higher scientific value than any of the others. It seems to have originated with Gensanne, who first applied the thermometer to this investigation, and ascertained the important fact that the temperature really increases with the depth. His experiments began in 1740, and were carried on in the lead mines of Giromagny, near Befort, to a depth of 1420 feet. Subsequent observations were made by Saussure in the deserted galleries of an excavation which had been made at the salt-works of Bex, in Switzerland. Humboldt and Freiesleben made numerous experiments in 1791, in the Freiberg mines; and the former observer, during his travels in South America, experimented on the temperature of mines to the depth of 1713 feet. Similar observations were made in Saxony by Daubuisson and Trebra, and in the lead and silver mines of Brittany; and in our own country by Messrs Bald, Dunn, and Fenwick, in the coal mines of the north of England,

and by Mr Fox in the Cornish mines. These observations were collected and arranged by M. Cordier in an admirable essay published in the "Mém. du Mus. d'Hist. Naturelle" for 1827, in addition to several experiments of his own; and after rejecting two-thirds of the observations as of doubtful value, it was ascertained that below the "stratum of invariable temperature" there was a constant rate of increase from above downwards of 1° Fahr. for about every 45 feet of descent. Subsequent researches have shown that the rate of increase is 1° Fahr. for every 60 feet of descent. All the observations, whether on the air, the water, or the rock of subterranean cavities, agree in this general law. These experiments are therefore justly regarded as affording positive proofs of an internal heat.

VI. *The Configuration of the Earth.*—Mathematicians assert that the form of the earth is just what it should be, provided it had been originally fluid; its equatorial diameter exceeding its polar diameter by about 27 miles. In connection with this argument in support of the theory of a central heat, it will be necessary to allude to the bold speculation of Sir W. Herschel, La Place, and other modern philosophers, in regard to the formation of planetary bodies. This speculation depends upon certain sublime and as yet unexplained discoveries in astronomy. It was observed that many of the fixed stars, when examined by the telescope, appeared like brilliant points surrounded by an extensive nebulous atmosphere. Other self-luminous spots or patches of vapour have been seen varying in brightness in different parts, and having various forms of outline, and to these luminous appearances the term of nebulæ has been applied. Herschel at first conjectured that the nebulæ were composed of stars at incalculable distances, and that they might be resolved into individual stars by the aid of more powerful telescopes; but he subsequently ascertained that the remarkable nebulæ in the constellations of Orion and Andromeda, although brilliant enough to be seen by the unassisted eye, were utterly irresolvable even in his gigantic telescopes. From extended observations on the circular

irresolvable nebulæ in the separate individuals of which a central condensation and brightness was observed gradually to increase until it assumed a star-like character, Herschel inferred that physical changes were actually taking place in a thin luminous haze capable of receiving impulses; and that this might be the process by which the original elements of matter were condensed into a brilliant sun. This was the basis of the celebrated "Nebular hypothesis," afterwards extended by La Place, who not only applied it to account for the creation of suns from self-luminous vapours, but for the formation of planets from rings of nebulous matter thrown off from these suns during the process of condensation, and of satellites from the planets as they in turn became solidified. The earth's crust is found to be almost entirely composed of four minerals—silica, alumina, magnesia, and lime; but each of these minerals consists of the elements silicium, aluminium, magnesium, and calcium, combined with about 43 per cent. of oxygen. It is known that very high temperatures are unfavourable to the union of oxygen with other elements, and that a great heat can convert every mineral known substance into vapour; and taking these facts along with another—namely, that the components of the rocky strata which constitute the crust of the earth would in a separate state occupy 2000 times the space they now occupy—we shall at once perceive that, under the action of the high primeval temperature supposed, this globe would put on an appearance not very unlike that presented by the nebulous stars to the astronomer. The nebular hypothesis assumes that before the arrangement of the earth into that complex and beautiful structure it now presents, it consisted of a round mass of incandescent vapour hung in space, uninfluenced by any force except the gravitation of its parts to each other. This force of gravitation would not act equally on all its parts, but would affect some to a greater degree than others; and the consequence of this would be that the particles would arrange themselves in the ratio of their respective densities. There would be accumulated round the central nucleus the fluid matter which now constitutes the interior part of the earth, and

above that, all those mineral oxides which can be raised into vapour at a high heat. Next, there would be the great body of waters as a highly rarefied vapour, and forming a vast atmosphere enveloping the incandescent globe beneath; and above all, the air would be expanded out into space, comparatively speaking, to an almost unlimited extent. Heated bodies, when suspended in space, radiate heat in all directions, and the earth would do the same. The radiation would be assisted by atmospheric currents. Air and watery vapour have their specific gravity increased by cold, and diminished by heat; and this law would act as follows:—The strata of vapour in contact with the incandescent surface would have their temperature higher than those at a greater height above it, and would be pressed upward, and carry their heat along with them into the higher regions, where it would be lost by radiation into space; whilst the colder and denser strata from above would descend and come in contact with the surface in their turn, and become heated and be pressed upward in succession. After a time, the temperature at the surface would be much reduced, and if the materials were good conductors of heat, no crust would be formed; for, as fast as the heat of fluidity was lost by radiation, it would be supplied from below, and by this process going on until the temperature of the whole mass fell to the same standard, it would become solid throughout. It is found, however, that the materials which constitute the crust of the earth are bad conductors of heat, and this would influence the rate of cooling. For the heat lost by radiation being greater than that derived from below, a time would come when the heat necessary to fluidity would be finally carried off from the outer stratum, in consequence of which it would become solidified. And now the temperature having been reduced, changes would occur in the gaseous envelope. The first of these would be the deposition of the metals, mineral oxides, and sulphurets; and after the temperature fell to a little below 212° Fahr., water would be formed by the condensation of vapour in the atmosphere, and would fall in rain. This would lower the temperature at once, because water in passing into vapour absorbs a vast

quantity of heat, which it would carry upwards with it until it lost it by radiation, when it would again become condensed and fall in rain as before. As the crust cooled, its internal capacity would become diminished by contraction, and as it could not compress the fluid contents into a smaller space, it would itself give way, and large rents and fissures would ensue. Through these rents water could easily descend to the melted matter beneath, and the consequence would be the formation of a prodigious quantity of steam under a very high temperature and pressure. This would produce further disruption and upheavings of the crust, while the rents becoming filled up by the fluid matter from beneath, might, in some instances, overflow the consolidated strata, and by cooling more rapidly, would assume a different mechanical structure and constitution from that of the already formed crust. Volcanoes may have originated about this time, and have been the means of lessening the effects of subsequent occurrences of a like kind, by affording a more ready escape to the vapours afterwards generated. These, however, would still be produced, in consequence of the successive contractions of the earth's crust, and would give rise to elevations and depressions that are observed to have taken place at the surface of the earth. This may be supposed to have constituted the primitive period, at the conclusion of which organised beings were called into existence. The nebular hypothesis, although supposed to give considerable support to the Huttonian theory, must be carefully distinguished from the Huttonian theory itself. The application of the theory of a central heat to explain certain geological phenomena may now be briefly stated.

1. *The Thickness of the Earth's Crust.*—As the cooling of the earth's crust, according to the theory, is a progressive change, there was a time when it was much thinner than at present, and during these early periods changes from contraction must have been very frequent, for every new layer as it cooled beneath would contract and press upon the fluid part below, and in the effort would be rent in many places. It appears as if several of these rents were still in existence. There seems to be a great one passing from the

West Indies down the coast of South America and across the Pacific. It has a long line of volcanoes marking its course, and those districts situated over it are the very centres of earthquake violence.

2. *Secondary Formations.*—The probable conditions under which the primitive rocks were formed have been already mentioned. The secondary class have evidently originated from the disintegration of the older formations. Two facts are ascertained in regard to the secondary formations—first, that they were arranged in their present state by the action of water; and next, that they were deposited after the creation of organised beings. And from these facts follows the conclusion that this deposition must have taken place after the temperature of the surface had fallen far below 212° Fahr.

3. *Igneous Rocks.*—The igneous rocks have always been held as a strong argument in favour of a central heat. They are supposed to consist either of a central fluid matter, or of primitive rocks melted and protruded from below. Their appearance is against the supposition; but this has been ascribed to the rate of cooling. Basalt or greenstone, if melted and cooled rapidly, forms a perfect glass; but if cooled slowly, each passes into a gray crystalline stone.

4. *Volcanoes.*—By the theory, volcanoes are assumed to be natural vents through which elastic vapours of various kinds make their escape, which might otherwise cause serious derangements in the crust of the earth. Some are supposed to exist over a fissure in the crust, which descends to the molten matter beneath; others, to have their origin nearer the surface—such are those that produce periodical discharges of lava, watery vapour, and the emission of flame.

5. *Earthquakes and Hot Springs.*—Various theories have been proposed to account for the phenomena of earthquakes, but the theory of a central heat would appear to afford a more easy explanation than any derived from chemical causes. It is known with what facility water descends between the rocky strata, and if it arrive, as it may easily do, to the point where even water boils—viz., about 10,000

feet—steam will be generated. This will separate the strata a little further, more water will sink down until an expansive force is formed sufficient to heave up the superincumbent strata, and when steam escapes, either by a volcanic vent or into the bottom of the sea, the rapid vibratory motion will be produced, which constitutes the earthquake. Hot springs are explained on the same principle—only, in their case, the water does not arrive at so great a depth before it is again returned to the surface. Such, then, is a brief summary of the celebrated Huttonian theory of the earth, and the principal geological problems which it is supposed to explain.

I have been induced to collect and arrange the foregoing facts and arguments which have been advanced in support of the theory of a central heat, chiefly as suggestive, and pointing out to us the many and difficult questions that yet remain to be solved before a true theory of the earth can be hoped for. Setting aside the greater problems, which, in the present state of science, are almost beyond our reach, I shall mention two lesser ones, but still important as bearing directly on the theory, and capable of solution by observation and experiment.

The first is on the *Aqueous, or the Igneous origin of Granite.* This problem is generally assumed as sufficiently established, but it is very far from it; and the valuable and carefully conducted experiments made by Mr Alex. Bryson, which are well known to the members of this Society, are directly opposed to the view of its igneous origin.

Secondly, some interesting *Experiments on the Metamorphic Rocks,* if not altogether against the theory of igneous metamorphism, have proved, in some instances at least, that the temperature could not have been very great. The experiments were made by exposing thin plates of rocks, or crystals cut in certain directions, to the slow action of solutions of acids and alkalies of different degrees of concentration. The result of this action is the gradual removal of some or all of the bases, a residue being left, the structure and composition of which indicated the mode of formation of the original rock. The residue or skeleton represents, for instance,

in the case of the lower metamorphic limestone shales, the sand of the original sea-bottom prior to its infiltration with calcareous matter. The details of this highly interesting field of inquiry are contained in a report to the British Association for 1859, on the "Results obtained by the mechanico-chemical examination of Rocks and Minerals," by Alphonse Gages, Curator of the Museum of Irish Industry.

The Huttonian theory, so far as it is founded upon the old hypothesis of a central heat, can only be accepted as a bold speculation. Simple and grand in its outlines, and affording easy and plausible explanations of many remarkable and mysterious phenomena in connection with the physical arrangement of the earth, it was readily adopted by scientific votaries, and became a formidable rival to the Wernerian system. Whatever objections may be urged against philosophical speculation in the abstract, it cannot be denied that it supplies a stimulus and gives a direct aim to inquiry and investigation on the science it bears upon. And the progress and present position which geological science has attained is doubtless due in a great measure to the rival schools of Hutton and Werner. So rapid, indeed, has been the progress of geology, that it may be safely affirmed that there are few, if any, attached to the study of this department of science, who are at present either Wernerian or Huttonian in the sense which, in the early period of this century, was comprehended under these designations. The necessity of restraining speculation and disregarding premature theories of the earth has been fully recognised. "The geologist has discovered the importance of attending to the geological relations of the modern strata, and the laws which influence the physical and geographical distribution of the present races of organised beings; in order that, by proceeding from the *distinct to the obscure*, he may qualify himself for illustrating, with a greater chance of success, the various changes which the crust of this globe has undergone." By this method, the discovery of facts that are accessible to observation, and that can be tested by experiment, has gone on with a rapidity which the advance of theory has been unable to overtake. This need not dis-

courage us, however, for by patient and continued observation, combined with experimental research, it may be our privilege to trace and connect a series of phenomena whereby Almighty intelligence has thought fit to manifest His power and purpose. The highest aim of science is the discovery of a law, and every law that we discover becomes an additional manifestation of an intelligent and a supreme Lawgiver.

On the motion of Mr DAVID PAGE, a cordial vote of thanks was given to Dr M'Bain for his able and interesting address, and also for his valuable services while President of the Society.

I. *On the Strata discovered in making the East of Fife Extension Railway, with special reference to the Brick-Clay Beds and their Fossil Remains.* By the Rev. WALTER WOOD, Elie, Fife. Communicated by JAMES M'BAIN, M.D., R.N. [Plans and Sections of the Railway were exhibited in illustration.]

The East of Fife Extension Railway commences at the Kilconquhar Station of the Leven and East of Fife Railway, and terminates at Anstruther, a distance of about six miles. The cuttings are not heavy, and are almost entirely through the boulder-clay and more recent deposits; the subjacent rock being reached only in one or two places. It is somewhat singular, that although Elie House, a little distance to the north of the line, is built upon Trap Tufa, and though the same rock appears in several places on the shore to the south, it is never touched by the railway except at the farm of Ardross, where there is a pretty deep cutting through it. It presents there the same appearance as on the shore, being distinctly stratified, with many faults and slips, and intersected towards its junction with the neighbouring rocks by numerous veins of calcareous spar. The junction, however, does not appear in the cutting, as the Neptunian rocks on both sides have been removed by denudation. There is an instance within the cutting of a slip, where the contiguous surfaces have by friction been polished till they have ac-

quired an almost silky lustre, and where grooves and scores in the rock are discernible, showing with what force the contiguous portions of the rock have pressed against each other. The writer had the pleasure of pointing out this interesting phenomenon to Professor Torell during his recent visit to this country, and of receiving from him a confirmation of the view now indicated.

In the other instances in which the cutting reaches the rock, it discloses one or other of the members of the coal-measures, such as shale, sandstone, &c.

Next to the rock lies the boulder-clay, where it has not been denuded. The principal section of it is at Elie Bridge (the bridge under the Elie and Kilconquhar Road), where it appeared as a hard *till,* maintaining a perpendicular face in the cutting, and full of boulders, some of which were resting on the rock, and some embedded in the till. These boulders were almost universally of greenstone, of various sizes, and scored in that peculiar manner which has been referred to glacial action. From under one of these boulders the writer took some fragments of wood, apparently of birch or hazel. But besides this hard till, there is a softer and more unctuous blue or reddish-blue clay, which appears at Kilconquhar Station; at Elie, west of the bridge at the station; at St Monance Station; and at Anstruther Station, beds of considerable thickness, besides presenting less important sections at several other places on the line. It would be premature to take for granted that it is precisely the same bed of clay which is displayed at these several places. At Kilconquhar, and, it is believed, at Anstruther, it has been wrought as a brick-field. The most careful examination has failed to detect any shells at Kilconquhar, nor have any, so far as is known, been found at Anstruther. At St Monance, it is said that a shell was found by one of the navvies, but unfortunately it has not been preserved. But at Elie, in the locality already mentioned, specimens have been found of the *Saxicava rugosa,* and of the *Astarte elliptica.* The junction between this unctuous clay and the hard till formerly mentioned is immediately west of a level crossing between Elie Bridge and Elie Station Bridge. Both

beds lie upon the rock, but the one does not pass into the other. A tongue of the overlying sand passes down to the rock between them.

The same bed of clay crops out at high-water mark, on a lower level than Elie Station, which is the lowest point of the railway. The shells in it at that point were first discovered by the Rev. Thomas Brown. It was visited this summer by Professor Torell, who found specimens of the following shells:—*Saxicava rugosa*, *Yoldia* or *Leda truncata*, *Pecten greenlandicus*, *Yoldia pygmæa*, *Bulla* (*sp.*), *Nucula inflata*, *Actæon* (*sp.*), *Bullanus porcatus*, *Crenella lævigata*, and *Astarte elliptica*. Two of these species, as he told the writer, he had himself picked up, lying side by side in front of the great glacier of Spitzbergen.

Immediately above the clay is a layer of peat, which first appears in the cutting between the bridges as several thin seams, with sand (apparently blown sand) intervening. These dip very rapidly towards Elie Station, where they form a bed of peat not less than 10 or 12 feet thick, mixed with much sand and many fresh-water shells. On the shore, where the same bed crops out above the clay, it is very much thinner. It may be added, that over the whole town of Elie, whenever excavations have been made down to the clay, a stratum of peaty matter has been found immediately above it, full of branches of oak, birch, and hazel, and even many hazel nuts. These may have been contemporaneous with the submerged forest in Largo Bay, described by the late Professor Fleming.—" Trans. Royal Soc. of Edin.," vol. ix. p. 421. Some inquiries are about to be instituted, in order to determine this point if possible, and the result will be communicated to the Society.

Thin veins and streaks of peat are also to be met with in other places among the strata which overlie the clay, but only at Elie Station do they form a bed of any thickness. It is deserving of remark, that where the bed of peat occurs the strata of water-borne sand and gravel disappear, and are succeeded by blown sand. It also happens that this occurs simultaneously with the substitution of the unctuous clay for the hard till; but this may be an accidental circumstance.

The strata above the clay, where no peat intervenes, are sand and gravel. A good section of these is still to be seen near Elie, about a mile south of Kilconquhar Station, at a place where ballast is taken for the use of the line. The lowest strata at this point are fine sand, white and brown, and lie nearly level. Above them are strata of sand and gravel dipping east, which again are cut off by similar strata dipping west. The gravel is not much waterworn, often scarcely at all. A piece of shale, a foot square, and not more than a quarter of an inch thick, was picked out from among the gravel, so friable, that it is scarcely possible to conceive that it had been exposed to any rude action of water. The same alternations of sand and gravel, fine and coarse, are exhibited along the line wherever a section is visible, and never depart much from the level, what dip there is being generally to the east. Among the gravel occasionally occur nodules (so to speak) of fine, clear, bright-coloured sand, without cement or cohesion. Can these have been frozen lumps at the time the gravel was deposited?

It may not be altogether out ot the way to add, that at the spot already mentioned, in excavating ballast, the workmen came upon an ancient tomb, of a funnel shape, about three feet deep, and the same width across the mouth. It was lined with slabs of stone, and covered with the same laid horizontally. A few small pieces of bone were found in it, undoubtedly human, but they had been disturbed before they were seen by any one able to judge of their character, or to give a distinct account of them.

Wednesday, December 23, 1863.—James M'Bain, M.D., R.N., President, in the Chair.

The following gentlemen were elected Office-Bearers for the Session :—

Presidents.—David Page, Esq.; William Turner, Esq., M.B.; Thomas Strethill Wright, M.D.

Council—George Berry, Esq.; A. M'Kenzie Edwards, Esq.; Alexander Bryson, Esq.; John Anderson, M.D.; William S. Young, Esq.; James M'Bain, M.D.

Secretary.—John Alexander Smith, M.D.

Treasurer.—George Logan, Esq., W.S.
Assistant Secretary.—James Boyd Davies, Esq.
Honorary Librarian.—Robert F. Logan, Esq.
Library Committee.—Thomas Robertson, Esq.; R. Traquair, M.D.; Andrew Taylor, Esq.

The following Donations to the Library were laid on the table, and thanks voted to the Donors:—

1. Canadian Journal of Industry, Science, and Art. New Series, No. XLIV., March 1863.—From the Canadian Institute. 2. Proceedings of the Academy of Natural Sciences of Philadelphia, Nos. VII., VIII., IX., July, August, September 1862.—From the Academy. 3. Jahrbuch der Kaiserlich-Koniglichen Geologischen Reichsanstalt, 1863, XIII., Band. Nro. 1, Janner, Februar, Marz.—From the I. R. Geological Institute of Austria.

I. *Two Specimens of Egyptian Geese* (Anser Egyptiacus) *were exhibited by* John Alex. Smith, M.D.

The birds, a male and a female, were shot in the neighbourhood of Dunbar, in the beginning of this month, and were sent by Mr Small, bird-stuffer, George Street. They are natives of the north of Africa, and of the south-eastern parts of Europe, and have been kept in a semi-domesticated state in various parts of England and Scotland. Several instances of single specimens of the bird, as well as small and even large flocks, apparently in a perfectly wild state, have, however, been observed in England at different times; and it has now been admitted into the list of birds which occur as occasional visitors to Britain. In this instance, it is not improbable the birds may have escaped from the collection of some neighbouring proprietor.

Dr Smith was informed by Mr Sanderson, George Street, that a flock of these birds, in a wild state, had this summer frequented Loch Leven, where it is possible they may have nested, and one of them had been sent to Mr Sanderson for preservation.

II. *On the Central Heat of the Earth.* By Dr Stevenson Macadam.

Dr Macadam referred to the emission of fused matter, the ejection of hot water, and the rise in temperature, when we

descend into the interior of the crust of the earth, as affording evidence that there was a "Central Heat." The increase in temperature is such, that at no great distance all matter must be in a highly ignited state; and, according to some physicists, a large part of the nucleus of the earth may be in a white hot, and fluid state; whilst in the centre the matter may be in a highly rarefied and vaporised condition. The ordinary theory of accounting for the cold surface and the heated interior, is to assume that the solid film or crust rests on molten matter; but such a supposition is unlikely, as a film of solid water or ice cannot rest on hot water without becoming liquefied, and no more can a film of solid granite or mineral matter rest on a molten mass of the same material. The theory originally suggested by Dr Macadam, and explained to the Society, called into force the spheroidal state of matter. Water thrown into a highly heated vessel does not readily pass off into steam; in fact, the water does not touch the vessel, but rolls itself up into a spheroid, which remains at some distance from the highly heated vessel, and very slowly passes into vapour. Again, if a heated rod be plunged into water, the latter is repelled by the spheroidal force, and until the heated rod becomes reduced in temperature, there is scarcely any disengagement of steam; but whenever the rod becomes cooled down, then the water touches it, and passes off in steam. These experiments on the spheroidal condition of water when influenced by heated metal, Dr Macadam brought to bear on the central heat of the earth; and he assumes that our globe internally consists of three distinct portions, viz., 1*st*, A central nucleus in a highly ignited state; 2*d*, A space enveloping and surrounding this heated nucleus; and, 3*d*, A crust at a comparatively low temperature, the inner side of which is in the spheroidal state. The above arrangement is similar to that observed in an ordinary egg. The yolk of the egg represents the mass of matter in a state of igneous fusion; the white of the egg occupies the position of the space between the heated mass and the crust; and the shell of the egg corresponds to the outer crust of the globe. The outer film or *solid crust* of the globe will thus be influenced by two great

forces—gravitation, and spheroidal repulsion; the former tending to draw the crust towards the central nucleus, and the latter repelling the crust from the centre. The solid film of matter, therefore, on which we tread, will have assumed the position where the equilibrium of the two forces is established. Dr Macadam then referred to the importance of his theory of the spheroidal state in explaining the cause of volcanic phenomena, and the evolution of hot water from the Geysers of Iceland, and concluded by expressing his firm conviction, that the theory he had expounded, and which had a *reality in conception* to him, would be found to explain many obscure points in connection with the central heat of the globe, and the evolution of molten matter and heated water from the interior of the earth.

An animated discussion followed the reading of this paper, in which Mr Alex. Bryson, Dr T. S. Wright, Dr M'Bain, and others took part.

Wednesday, 27th January 1864.—WILLIAM TURNER, Esq., M.B, President, in the Chair.

William Jackson Elmslie, Esq., A.M., was balloted for, and elected a member of the Society.

The following Donations to the Library were laid on the table, and thanks voted to the donors:—

1. (1.) Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt, 1863, XII. Band. Nro. 2, April, Mai, Juni. (2.) General-Register der ersten zehn Bande des Jahrbuches der Kaiserlich-Königlichen Geologischen Reichsanstalt.—From the I. R. Geological Institute of Austria. 2. Canadian Journal of Industry, Science, and Art New Series, No. XLV., May 1863.—From the Canadian Institute. 3. Proceedings of the Academy of Natural Sciences of Philadelphia, Nos. IX., X. XI., XII., September, October, November, December, 1862.—From the Academy. 4. Section of the East of Fife Extension Railway from Kilconquhar to Anstruther; copied from the Original Plans and Sections, by the Rev. Walter Wood, in illustration of a paper read before the Society at a previous meeting (see p. 125)—From the Rev. Walter Wood, Elie. 5. Transactions of the Royal Scottish Society of Arts, Vol. VI., Part iii., 1863.—From the Society.

The following communications were read:—

I. *Deductions from the Hypothesis of the Internal Fluidity of the Earth.* By William Stevenson, Esq., Dunse. Communicated by George Logan, Esq., W.S.

It is now all but universally admitted by geologists, that the globe which we inhabit was, at a certain remote period, in a state of complete fusion through intense heat, and that from this state it has been gradually cooled down to its present temperature by the process of radiation of its surface heat into space. The object of this paper is to show a few of the results flowing from these premises, assumed to be correct;—certain postulates being further granted of a character as nearly approaching the truth as the present imperfect state of our knowledge regarding the subject will admit.

1. It has been well ascertained that, in descending into the interior of our globe, after passing through the stratum affected by the solar radiation (which nowhere appears greatly to exceed 100 feet), a gradual increase of temperature is experienced, owing to the internal parts still retaining a large portion of their original heat. If, then, we assume that the increments of temperature in descending are uniform and equal to 1° Fahrenheit for every 45 feet of descent,* and that the limit of the solar influence is 100 feet below the surface, the temperature of boiling water will be reached in this part of the world (taking 52° as the surface temperature) at $(212° - 52°) \times 45$ feet $+ 100$ feet $= 7300$ feet below the surface, and a red heat (or say 752°) at a depth of 31,600 feet, or a very little less than six miles. The convex superficies of the earth = 196,813,000 square miles, and taking a mile and a half as the thickness of that part of the crust of which the temperature is under 212°, we have 295,219,500 cubic miles of a lower temperature than boiling water, the heat of the whole remaining portion of the earth's mass being

* I am aware that some observations give a result of only 1° in 60 feet of descent as the rate of increment of temperature; but whatever may be the rate, it can only affect the numerical results, not the principles involved in this paper.

more intense. The cubic contents of the earth amount to about . . . . 259,431,755,889 miles, from which deducting that part of which the temperature is under 212°, 295,219,500 miles, we have . . . . . . 259,136,536,389 cubic miles of a temperature exceeding that of boiling water. From this it appears that the proportion which that part of the globe of which the temperature is below 212° bears to that possessed of higher degrees of heat, is as *one* to 878 nearly. In like manner, the proportion which that part of the earth's mass possessed of a temperature of 752° or under bears to that of a higher temperature, is as *one* to 218.

2. Cast iron fuses at about 2786° Fahr. Taking the present mean temperature of the whole surface of the earth at 67°, the temperature of molten cast iron will, according to the foregoing assumptions, be reached at a depth of 40,785 yards, or 23·173 miles. This, then, would be the average thickness of the solid crust of the earth at present, supposing the materials of which it consists to possess about the same degree of fusibility as cast iron. By descending 45,000 yards, or 25·56 miles, we should experience an increase of heat amounting to 3000° Fahr. At such a depth the temperature (3067°) would probably be sufficient to hold in a state of fusion by far the greater part of such substances as there exist, unless, which is by no means probable, they are much more infusible than the great bulk of the substances composing that part of the crust with which we are more intimately acquainted.

3. Since (by hypothesis) the whole earth was at one time in a molten state, let us assume that the surface temperature was then 3067° or 3000° more than the mean surface temperature at present. In order, then, that the crust should be cooled down to its present state, it would require to part with an amount of heat equal to $\frac{3000^\circ}{2}$ or 1500° upon the whole, the upper surface losing 3000° of heat, and the lower or interior surface *nil.*

4. The contraction resulting from refrigeration would necessarily shorten the earth's radius. To ascertain the amount of such shortening, let it be granted that the materials

of which the crust is composed contract uniformly by diminution of temperature, and at the rate of $\frac{1}{1248}$* for every 180° Fahr., which is the rate of contraction of flint glass. Then we have 180° : $\frac{1}{1248}$: : 1500 : $\frac{25}{3744} = \frac{1}{149 \cdot 76}$, and $\frac{1}{149 \cdot 76}$ of 45000 yards (taking this as the thickness of the crust) = 300·48 yards, the amount which the radius would be shortened by a loss of 3000° of surface temperature. The circumference of the earth would thus be reduced by 300·48 × 3·1416 × 2 = 1886·976 yards,† so that a point on the surface at the equator would have its diurnal orbit lessened to this extent. Since the space moved over by the crust in its daily axial revolution would thus be diminished, whilst its *momentum* continued the same as before, a shortening of the day to a certain amount would necessarily take place. Suppose now the original diurnal period of the earth to have been 24 hours, then 43,781,760 yards (or 24,876 miles, being the circumference of the earth) : 1887 yards : : 86164″ (24 hours) : 3″·7136, which would be the amount of the daily acceleration of the crust, but for the retarding influence of the friction of its lower surface upon the molten interior.

5. The loss of heat at the surface being assumed = 3000°, the corresponding contraction will be $\frac{1}{74 \cdot 88}$, and the superficial contraction of a great circle of the earth = $\frac{24876}{74 \cdot 88}$; or say $\frac{25000}{75}$ = 333⅓ miles, which would be the aggregate width of the fissures opened on the whole circumference of the earth by a reduction of temperature to this amount. This is equivalent to 195½ yards for every degree of Fahrenheit.

6. By this refrigeration of the crust, and the consequent contraction of all its parts, its capacity would obviously be diminished, so that it would grasp the internal molten mass with greater and greater force, until the *tension* became extreme, when fissuring would ensue and molten matter would be erupted, until the capacity of the crust and the quantity of

* According to the very careful experiments of Mr Adie, the contraction of a column of Ratho greenstone cooled 1000° was 4½ per 1000. For 180° this would amount to $\frac{1}{1234 \cdot 5678}$, or a little exceeding that of flint glass, so that the rate above assumed is perhaps not very far from the truth.

† *Or 1·2578 yards* for each degree of Fahrenheit.

matter inclosed were mutually adjusted to an equilibrium. The diminished capacity due to a loss of 3000° of surface temperature would be about 33½* millions of cubic miles. This then would, according to hypothesis, be the volume of the whole igneous rocks ejected since the surface of our globe was possessed of the temperature above assumed.

7. The aggregate width of the fissures opened in the crust being (as by Par. 5) 333⅓ miles in the direction of a great circle of the earth, may be represented by two wedge-shaped ditches surrounding the globe, one being equivalent to the sum of the fissures in longitude, and the other to the sum of fissures in latitude. The length of these ditches may be taken at 24,876 miles, their width at the surface (average being half of 333⅓ miles) 166,833 miles,† and their depth 25·56 miles. Hence, $24876 \times 166{\cdot}833 \times \frac{25{\cdot}56}{2} \times 2 =$ 105,971,760‡ cubic miles, the quantity of igneous matter required to fill up the whole of these fissures. This would be equal to two ridges engirdling the earth, each having a width at base of 166·83 miles, and a height of 25·56 miles.

8. Supposing the density of the earth to increase in descending in an uniform ratio, from 2 at the surface to 20 at the centre, then at a depth of 23·1796 miles (or probably not far from the upper limit of the molten matter of the interior), the specific gravity of the materials there existing should be 2·1055. Or, taking the surface density at 2, and at the centre 22, we have at the above depth the specific gravity of 2·1172. Taking the means of these, the density at 23·1796 miles will be 2·1113, and taking 23·2 miles as the thickness of the crust, its specific gravity on an average will be 2·0556.

9. Assuming as before the crust to have lost, upon an average of the whole, 1500° of heat, and the resulting con-

* 197,000,000 (square miles of earth's surface) $\times \frac{300{\cdot}48}{1760} =$ 33,580,000 cubic miles.

† A deduction from the width of the fissures at the surface should be made on account of the co-resulting shortening of the radius; but as this would amount only to about the 300th part of the whole, it is unnecessary to take it into account in the calculation.

‡ 35,324 cubic miles would be required to fill up the fissures opened by the contraction resulting from the crust parting with *one* degree of heat.

traction to be at the rate of $\frac{1}{1248}$ (lineal) for 180° Fahr., the lineal contraction will be $\frac{1}{150}$, and the consequent increase of density $151^3 - 150^3 = \frac{1}{49 \cdot 668}$. Hence $\frac{2 \cdot 0556}{49 \cdot 668} + 2 \cdot 0556 = (\cdot 04138 + 2 \cdot 0556) = 2 \cdot 09698$ = the average density or specific gravity of the crust after refrigeration. But this is less than that of the immediately subjacent molten matter (2·1113, Par. 8), so that, if a portion of the crust should be completely detached by fissuring, it still would *float* upon the fluid mass. If the specific gravity of the crust increased on account of refrigeration in a higher ratio than the density in descending, the conservation of its stability would depend wholly upon its retention of the arched form, and if portions of it should by any means be separated, they would necessarily sink. In the relations, then, which these two ratios (provided our deductions are legitimate) bear to each other, we cannot but observe a most beautiful and striking example of design and providential arrangement.

10. It appears sufficiently obvious that the upper surface of the molten interior must, to a certain considerable extent, be *unequal*, in accordance with the greater inequalities of the external surface of our globe; and that the depth from, say, sea-level down to the internal fluid must vary considerably at different places. The solid crust must be nearly as thick below the bottom of the ocean (through several miles deep) as under the surface of dry land, whether we suppose the main oceans to have occupied nearly their present beds for an indefinite time, or what is more consistent with geological facts, to have repeatedly changed them, heat being conveyed from the bottom of the sea to its surface by the process of convection with great rapidity, and the temperature of the whole body of water, so far as the subterranean sources of heat are concerned, kept nearly the same. The figures of the isothermal planes in the interior cannot therefore be those of concentric spheroidal surfaces, but must deviate therefrom to a certain extent, waving in a manner similar to, though differing in degree from, the undulations of the surface of the land and sea-bottom.

11. The consequence of the contraction of the earth's *radius from* refrigeration, would (as has been already shown,

Par. 4) be an augmented velocity of rotation of the crust as compared with the interior, so that whereas the latter required the same time as before to complete a diurnal axial revolution, the former would accomplish the same in a somewhat shorter period. Owing, however, to the inferior surface of the crust being in contact with the superior surface of the internal fluid, a portion of the surplus velocity of the former would be communicated to the latter. Were the surfaces in contact perfectly free from inequalities, and truly concentric, the surplus force of the crust would be wholly expended in gradually increasing the velocity of rotation of the interior; but since, as we have seen, this is far from being the case, it will at once appear evident that a portion of this surplus is converted into *a gradually up-heaving force*, operating in a direction from east to west, or contrary to that of the earth's rotation on its axis. The total amount of the force of which a portion is thus converted into the "*up-heaving force*" of the geologist, is, according to the assumptions and calculations we have employed, equivalent to the *momentum* of the whole solid crust of our globe (say 4998* millions of cubic miles) moving over a space of 471·75† yards in 24 hours.

12. According to the hypothesis of the density at the surface being 2, and at the centre 21, it appears by calculation that at the depth of 106¼ yards the mean specific gravity of the materials occupying that position would be 2·00028991. Suppose, then, a *crust* to be formed *without contracting*, of this thickness, its specific gravity as a mass would be about 2·00014496. Such a crust would have no tendency to sink in the subjacent molten mass. But suppose that it should part with 1500° of heat, whilst the temperature of the fluid mass beneath remained undiminished, then in this case the resultant contraction and consequent increase of density would be $\frac{1}{49 \cdot 668}$ (Par. 9), and the specific gravity of the mass augmented to 2·04041526,

* 196,000,000 (square miles of surface) × 25½ miles (thickness of crust).

† 1887 yards (arc of excess as by Par. 4) halved for mean between the upper and lower surfaces of the crust, and again halved for the mean between the equator, where the maximum is attained, and the poles, where the effect is zero.

which, being greater than that of the immediately subjacent mass, the crust so formed would necessarily sink. In like manner it may be shown that all crusts under a certain thickness would sink, whilst all above such a thickness would float. It thus appears that the thin crusts originally formed would sink and undergo total or partial re-fusion until a certain thickness of solid matter was attained. By this arrangement the refrigeration of the superficial parts of our globe would proceed with far greater rapidity than if the thin crust originally formed had maintained its position, as in this case the heat from the interior could only have reached the surface by the slow process of conduction through a solid mass of very low conducting powers. In this, then, there also appears evidence of design in hastening the progress of our globe through its uninhabitable stages, that it might be the sooner fitted for the habitation and enjoyment of the sentient beings for whose use it was destined.

The deductions contained in the preceding paragraphs are humbly presented to the consideration of all who are interested in the study of geological physics. Though some of the assumptions founded upon may perhaps be called in question, and although in the calculations many corrective elements have not been taken into account, it is hoped that at least glimpses of some important truths have been obtained, sufficient to attract the attention of more competent investigators. The astonishing progress which the physical sciences have made within the last half century encourages us to hope that the time is not far distant when sufficient data shall be obtained to enable us to work out the solution of many of the most important problems connected with geological dynamics. Even now, in studying the phenomena resulting from the refrigeration of our globe, we obtain a clue to the nature and *modus operandi* of some of the causes by which the varied configurations of the earth's surface have, in the present as well as in the past geological epochs, been produced. For example, in the fissures opened in consequence of refrigeration, we see at once the origin of *mountain* chains. We can imagine the gradually cooling

and contracting crust grasping with ever-increasing force the internal molten mass, until the tenacity of its materials could no longer resist the tremendous reaction. Then would a disruption ensue, and vast quantities of igneous matter be ejected from the yawning fissures. The lips of the chasms would then re-approach and finally press powerfully against each other, producing the phenomena of anticlinal and synclinal foldings so familiar to the geologist. Again, in the gradually up-heaving force generated by the accelerated diurnal motion of the crust, in consequence of its contraction through refrigeration, is seen the cause of those repeated risings and subsidences which have been going on in all geological periods, from the most remote down to the present. In the changes so effected in the relative distribution of sea and land, we recognise one of the most influential climatic agencies, by means of which the temperature due to the position of a place in latitude is powerfully modified. Connected also with the distribution of sea and land is that of terrestrial magnetism, as is at once apparent from a comparison of a map of isothermal with one of isodynamical magnetic curves. So closely related, in short, are all the parts of the great system of nature, that a discovery in one department becomes a key to the solution of difficulties in others. Geologists are deeply indebted to the physical sciences for the powerful aid which these have furnished them in their investigations, and the physical sciences have already to a small extent been, and will undoubtedly in a great degree be, benefited by the researches of geologists.

On the motion of the President, the thanks of the Society were given to Mr Stevenson for his communication.

II. *Remarks on Dr Macadam's "Spheroidal Theory" of the Interior of the Earth.* By T. Strethill Wright, M.D.

Dr Wright commenced his paper by an enumeration of various circumstances under which fluids assumed the so-called "spheroidal" state, and explained the meaning of the

term " spheroidal." All fluids became spheroidal when released from the cohesive attraction of surrounding solids or fluids, and their release was due in every case to the interposition of a thin plate of air or vapour between the " spheroidal" globule and the substance over which it floated. It was a mistake to suppose that " repulsion" took place in these cases. The term " repulsion" had no meaning in physical science. The author then exhibited to the Society the production of the " spheroidal" state in fluids by various mechanical and electrical contrivances, and explained the mode of action of the latter. He then repeated the experiments of Boutigny by the aid of large and accurately adjusted plates of heated copper, on which globules and plates of various fluids rolled and floated without actual contact with the metal, and were thrown into various undulatory and symmetrical figures, such as crosses, transparent domes, toothed wheels, &c., by the intermittent action of compressed vapour, while forming and escaping from their lower surfaces. At a late meeting of the Society Dr Macadam had advanced, that the outer shell of the earth was maintained at a considerable distance from its incandescent nucleus by the existence of the " spheroidal condition" on the inner surface of the former. Dr Wright dissented from Dr Macadam's theory, inasmuch as it was impossible that the shell and nucleus could be maintained at other than an exceedingly minute distance by the hitherto observed laws of spheroidal action; that matter, when maintained in the spheroidal state by heat, was subject to incessant motion and waste from evaporation, which would not only prevent the formation of a continuous shell, but would break up or distort that shell, if momentarily formed, by pressure from within: and that the observed shape of the earth was that which a mass of homogeneous inelastic fluid would take during rotation; while a compound mass (such as a fluid shell surrounding a fluid nucleus, and separated from it by a layer of elastic aeriform fluid) would either break up into a ring on rotation, or exhibit a bulging at its weakest parts —the poles. This actual agreement between the observed *shape* of the earth and its calculated shape as a homogeneous

fluid mass was, Dr Wright considered, fatal to Dr Macadam's ingenious and beautiful theory.

A discussion followed on the subject of this paper, in which Dr Macadam, Dr M'Bain, Mr Rhind, Dr Ferguson, and the Rev. Walter Wood, Elie, took part.

Dr Macadam stated that, having been specially alluded to in connection with this paper, he was desirous of making a few remarks. He felt more and more convinced of the probable truth of the spheroidal theory of the central theory, and nothing which Dr Wright had advanced had shaken, in the slightest degree, his confidence in the theory as being able to explain satisfactorily the existence of a cold crust of solid matter surrounding a central nucleus in an intensely ignited state. The conclusions which Dr Wright had arrived at were not tenable, as the heated vessel on which the spheroid of water moved about was comparatively at a needlessly high temperature,* and experiments made by Boutigny upon ice had shown that, when thrown on a heated surface, a portion of the ice passed into the spheroidal state, and then continued to reflect heat, leaving the remaining part of the ice still frozen.† The arrangement of the crust and central

* The temperature of the heated vessel in which water is thrown and passes into the spheroidal state, does not require to be above 339°·8 F. (340° F.); and it is manifest that a thin metallic capsule, with a Bunsen gas-lamp burning immediately underneath, will be at a much higher temperature than 340° F. The best mode of applying the heat to a vessel is to surround it by a bath of oil, the temperature of which can be easily regulated; or place the vessel in a basin-shaped depression in a mass of fire-clay which has been previously heated, and the temperature of which can be ascertained by a thermometer. Another mode of making experiments on the spheroidal state of matter, is to heat a solid ball of platinum before the oxyhydrogen blowpipe and plunge it into water, when the liquid will be observed to stand back from the heated ball, and gradually, as the metal cools down, the water approaches, and ultimately, when the ball is reduced to 340 F., the water for the first time touches the metal, and passes rapidly into steam.

† Boutigny will be acknowledged to be the principal authority on all experimental data connected with the spheroidal condition of matter; and his elaborate series of experiments and observations are not only conclusive, but may also be regarded as exhaustive of the subject. On the passage of ice into the spheroidal state, he says (*Annales de Chimie*, troisième série, tome onzième):—

" *Quarante-neuvième expérience.*—On fait rougir la capsule en fonte dont on

parts of the earth, according to the spheroidal theory, would throw the inner surface of the crust into the spheroidal state,

s'est servi pour l'expérience quarante-quatrième, puis on attache un morceau de glace du poids de 100 à 150 grammes avec un fil de fer fin, et de manière que le morceau de glace se trouve placé à une certaine distance du centre de la capsule. La boule d'un thermomètre disposé d'avance est placée au centre de la capsule, et seulement à une distance de 2 à 3 millimètres de sa paroi. Voici ce qui se passe : la glace se fond et passe à l'état sphéroïdal sans passer préalablement à l'état liquide ordinaire, et le thermomètre indique constamment la température de + 96°, 5, qu'il y ait ou non de la glace.

" Quand on n'a pas de thermomètre convenable à sa disposition, cette expérience peut se faire de la manière suivante.

" *Cinquantième expérience.*—On fait rougir une capsule en argent de 5 à 6 centimètres de diamètre, et on y projette un petit morceau de glace de 3 à 5 grammes, et quand la moitié à peu de près de cette glace est à l'état sphéroïdal, on saisit la capsule avec des pinces et on verse rapidement son contenu dans la main, si l'on a la main délicate ; au contraire, si l'on a la main calleuse, on le verse sur le dos de la main. Dans les duux cas, on éprouve d'abord une sensation de chaleur, ensuite une sensation de froid occasionée, l'une par l'eau à l'état sphéroïdal, et l'autre par le fragment de glace non liquefié qui ramène rapidement l'eau à 0 degré.

" Ces deux dernières expériences me semblent établir que la loi du passage de l'état solide à l'état liquide diffère de celle du passage de l'état solide à l'état sphéroïdal. Je reviendrai sur ce point en temps et lieu.

" En attendant, faisons remarquer que l'eau qui jouit d'un pouvoir réflecteur absolu à + 96°, 5 (vingt et unième expérience) absorbe tout d'un coup, pour ainsi dire, tout le calorique nécessaire pour prendre cette température (+ 96°, 5) au delà de laquelle elle ne s'échauffe plus. Pourquoi ? comment ? On l'ignore et on l'ignorera probablement toujours. Il y a là un de ces mystères profonds qui confondent la raison et qui mettent à nu l'impuissance de l'esprit humain."

Boutigny has not only thrown ice into the spheroidal state, but he has also *made* ice in the heated vessel by the addition of liquid sulphurous acid. Three of his experiments on the subject are given in the following quotation (*Annales de Chimie*, troisième série, tome neuvième):—

" *Douzième expérience.*—On fait rougir à blanc une capsule en platine, et l'on y verse quelques grammes d'acide sulfureux anhydre. En observant le col du ballon contenant l'acide sulfureux à la partie qui correspond à la main on voit bouillir rapidement cet acide, qui cesse immédiatement de bouillir lorsqu'il est dans la capsule, et il offre à l'œil de l'observateur tous les phénomènes physiques qui présente l'eau. Son évaporation surtout se fait avec une lenteur incroyable et sans aucun signe d'ébullition. Opère t-on par un temps humide, l'acide sulfureux s'opalise et perd de plus en plus sa transparence, puis il se solidifie, et l'on reconnaît avec étonnement que ce solide est presque entièrement composé d'eau. Le résultat serait différent si l'on expérimentait dans un air très-sec, alors l'acide sulfureux ne se solidifie pas, et il s'évapore sans laisser de résidu.

"*Avant de* passer à une autre expérience, faisons remarquer que l'acide

which would then totally reflect the heat radiated from the central nucleus,* and the disengagement of vapour from the

sulfureux bouillant se refroidit dans une capsule incandescente. Il en est de même pour les autres corps; l'eau bouillante, par exemple, traitée comme l'acide sulfureux, descend immédiatement à $+96°, 5$.

" *Treizième expérience.*—On verse goutte à goutte de l'eau distillée dans de l'acide sulfureux à l'état sphéroïdal, et cette eau se congèle instantanément, même quand la capsule est chauffée à blanc.

" *Quatorzième expérience.*—On plonge pendant une demi-minute environ la boule d'un petit matras contenant 1 gramme d'eau distillée dans l'acide sulfureux à l'état sphéroïdal, puis on l'en retire on le casse, et *on y trouve un petit morceau de glace.*

" Ainsi, dans cette expérience, on voit dans le même moment et dans le même vase l'équilibre de chaleur s'établir immédiatement entre l'eau et l'acide sulfureux, et cet équilibre ne pouvait pas s'établir entre l'acide et la capsule.

" La cause de la congélation de l'eau dans de l'acide sulfureux est, du reste, facile à comprendre; il suffit de se rappeller la loi de la température des corps à l'état sphéroïdal formulée plus haut. (*Voyez la onzième expérience.*)

" L'illustre Robiquet ne se trompait donc pas quand il disait dans son Rapport à l'Académie: ' Ces phénomènes méritent une attention bien sérieuse, et leur étude promet d'importants résultats.'

" Les expériences qui précèdent, particulièrement la douzième, ne m'autorisent—elles pas à dire que l'acide carbonique solide de M. Thilorier n'est autre chose que de l'hydrate d'acide carbonique, et que cet acide n'a été vu jusqu'ici qu'à l'état gazeux et à l'état sphéroïdal? L'analogie me parait frappante. Au reste, je me proposer d'étudier cet acide sous ce point de vue, ainsi que le chlore, l'ammoniaque, le cyanogène, etc.

" *Quinzième expérience.*—On fait chauffer à blanc la moufle d'un fourneau à coupelle; on y fait rougir une capsule en platine dans laquelle on verse 1 gramme d'acide sulfureux anhydre; puis on repousse la capsule au fond de la moufle, dont on ferme l'ouverture en se ménageant un petit espace pour observer l'acide sulfureux et livrer passage à l'air. Si le temps est sec, il s'évapore lentement sans bouillir, absolument comme à l'air libre, quoiqu'il soit soumis à une température excessivement élevée et à l'action de rayons calorifiques, qui se croisient dans tous les sens; mais, si le temps est humide, l'eau hygroscopique va se congeler dans l'acide sulfureux au fond de la moufle, et, finalement, *on retire de la capsule un petit glaçon d'un froid brûlant.*"

* The total reflection of heat by substances in the spheroidal state has been specially considered by Boutigny, and his experimental observations are numerous. It will be sufficient to give the following extracts from the *résumé* of the researches published by him.

Résumé 5, 6, and 7 (*Annales de Chimie,* troisième série, 1844, tome onzième).

" 5. Que les corps à l'état sphéroïdal jouissent d'un pouvoir réflecteur absolu à l'égard du calorique.

" 6. Que tous les corps peuvent passer à l'état sphéroïdal (?)

" 7. Qu'il n'y a pas de contact entre les corps à l'état sphéroïdal et les surfaces qui les font naître."

spheroidal lining would cease when the pressure increased, in a manner similar to the stoppage of vapour or steam from water at 212°, when the atmospheric pressure is increased. The distance between the central nucleus and the crust of the globe will be determined by the temperature of the nucleus, as the higher the temperature of the heated centre, then the further off will it repel or keep off the crust. Dr Macadam was still of opinion, that the only satisfactory theory which accounted for the compatibility of a cold surface and a highly ignited central nucleus was based upon the spheroidal condition of matter. The same theory, applied to the Geysers of Iceland, accounted for the discharge of hot water from these intermittent hot springs.

Dr WRIGHT, in reply, stated that Dr Macadam was mistaken in supposing that the plate on which Dr Wright performed his experiments was heated too highly; and this he showed to be the case by turning off the gas from the apparatus, when the water floating on the plate instantly came in contact with the latter, and exploded. It was not true that bodies in the so-called spheroidal state totally reflected heat. So far from that, they invariably became heated; and solids such as camphor floated on the plate until they became quickly entirely liquefied, and converted into vapour. It was also incorrect to say that the distance between the spheroid and the plate bore any relation to the heat of the plate. He found that after a certain distance had been attained, a further increase of heat was not attended with any effect. He maintained that temperature had really no essential relation to the spheroid state; that the whole phenomena depended entirely upon the adhesion of vapour to the surface of the spheroidal body, and could be shown in various liquids, such as solutions of soap, alcohol, albumen, essential oils, &c., perfectly well when they were in the cold state.

Wednesday, 24th February 1864.—Thomas Strethill Wright, M.D., President, in the Chair.

The following gentlemen were balloted for and elected Non-Resident Members:—George Bellairs, Esq., Crown Chamberlain and Receiver for Scotland, Mount Lodge, Portobello; James Burrell, Esq., late of Bengal, Birnam Lodge, Trinity.

The following communications were read:—

I. *Some Objections to the Nebulo-Geological Hypothesis, as stated in Dr James M'Bain's Opening Address to the Royal Physical Society.* By Patrick M'Farlane, Esq., Comrie. Communicated by Alexander Bryson, Esq.

The author commenced by stating that, before entering on the main object of his present paper, it might be as well for him to mention certain peculiar circumstances in which the paper was brought forward before the Royal Physical Society. "1*st*, The author had not the honour of being a member of the Society; 2*d*, His sentiments on certain subjects of high interest differ, and have long differed, and that widely, from those on the same subjects entertained, and that have been long entertained, so far as can be judged from published evidence, by the members of this Society generally, by its leading members especially, and more especially still by its late excellent and erudite President, Dr M'Bain; 3*d*, And what will seem the most peculiar of all these peculiar circumstances is, it is to that late President himself, whose views on the subject referred to are herein most directly controverted, that the author is indebted for the privilege of having this paper regularly read at this meeting." The author then proceeds to state "that the subjects referred to as in the meantime presenting so widely different aspects to the members of this Society (and seemingly to many other societies and individuals besides) from what they did to the author, are the *age*, *history*, and *present condition* of the stellar universe generally, and *those of this our own world in particular*. Judging of the former aspect from the description given in the able and comprehensive 'Valedictory Address' of your late President

as it appeared in the columns of the 'Edinburgh Evening Courant' of the 2d December last, and from several other and similar evidence, it seems to be the following:—That infinite space was originally sparsely filled with what the eminent French astronomer Laplace called star-dust. How this was the case, or how that dust acquired the requisite intense initial heat, attraction, and other qualities ascribed to it, neither Laplace nor Dr M'Bain has chosen to inform us." The author then follows up with what he considers a "fair and faithful sketch of what may be called the nebulo-geological hypothesis of this Society and of the present day. The author has thus united the two pieces under one name, as he is, and has all along been, convinced they are, and ever have been, virtually only different and mutually depending portions of one great whole." The author asserts that the nebular hypothesis was all along untenable on various grounds, one of which was the immense lapse of ages it required for performing its operations. But the strongest of all grounds, in the opinion of the author, for rejecting the nebular hypothesis, was that the Creator himself had plainly announced in His Word that he had, at the first completion of creation, framed all the merely physical universe summarily and in its highest degree of perfection. "What have been the findings of Science herself," asks the author, "on this point? A few years ago, as most of you are aware (although some appear to wish to conceal the fact), the Creator himself, as if resolved to rescue this part of his handiwork from the aspersions of man, snatched, through the instrumentality of the 'monster telescope,' every starry orb from the condition of ignoble dust to which it had been ground down and kept far too long, and restored it to its primitive condition, again a glorious sun! Of the late nebular hypothesis, let it be said, *quiescat in pace!*" And now, having performed his duty to that subject, let us give a glance, says the author, at the still remaining member of this indissoluble partnership. After some ingenious illustrations, the author says—"It is pleasant to find that however much the sentiments of this Society and those of the *author* differ, in the meantime, on other points, there is one,

so far as can be judged from various expressions, more or less definite, scattered throughout almost all the addresses, on which there is harmony, and that point is—that notwithstanding Laplace's old and futile attempts to displace the Creator from His own creation, we all firmly hold that the stellar universe, as well in all its details as in whole, is the handiwork of Supreme intelligence, wisdom, power, and benevolence." By an ingenious process of illustration and argument, the author proceeds to show that these attributes of Deity are inconsistent with the science of modern geology, and that the sooner the hypothesis of lengthened periods of geological time is given up *in toto*, the more will it be for our credit, both as men of science and otherwise. "But if," says the author, "there be any after all determined to abide by it, they should in common consistency still maintain the entirety of the hypothesis from the electrical convulsions of the nebular portion under the auspices of Dr M'Bain to the molten and crusty mass, and, amputating and casting away the present crude and cruel mode of supplying living creatures, engraft, in its stead, the far less repulsive mode of effecting the same end suggested by Lamarck, and just now pressed upon them by Huxley, Darwin, and Lyell. Then they would have, though still a mere ideal, a complete self-acting piece of mechanism extending from the scattered initial star-dust up through the sun-shaping and planet-spurting whirlpool to the molten globular mass, and from it again through the constantly heaving and frequently bursting crusty shell to its indigenous monad, and from the monad, through the monkey to the man,—nay, to man in his 'future state' of highest development; and then would the released Creator receive at least partial and negative justice by thus dispensing entirely with his interference."

Dr M'Bain said—In reference to the communication now read to the meeting by Mr A. Bryson, professing to be "Objections to the Nebulo-Geological Hypothesis," as indicated in his address at the opening of the session, he had only to remark that the allusion made to the nebular

hypothesis of Sir W. Herschel was merely intended to show that up to the present time the astronomical phenomena on which it is based are still unexplained by astronomers. He need only refer to the "Intellectual Observer" for November last, in which the Rev. T. W. Webb, M.A., F.R.A.S., in a communication entitled "Clusters and Nebulæ," gives a summary of the present astronomical state of the question. While there he found that the "monster telescope" has not yet "snatched every starry orb from the condition of ignoble dust, to which it had been ground down and kept too long, and restored it to its primitive condition, again a glorious sun." Mr Webb, referring to the resolvability of the nebulæ, says,—"Nothing seems to be absolutely demonstrated on either side; but admitting all the modern observations to be of equal weight, we may perhaps be drifting towards the supposition that the minute granulations into which those cloudy masses seem decomposable may not, after all, be stars, in the usual sense of the word; or that, as Secchi thinks, the brighter portions may consist of stars, while the fainter may be of another nature, and actually situated, as indeed Herschel had suspected, even nearer to us than some of the bright stars with which they seem connected." This is the only point in the paper by Mr M'Farlane that bears directly on physical science, the greater part of it being occupied with the peculiar cosmological hypothesis which appears to be entirely supported by metaphysical and theological reasoning, and consequently beyond the province and limits of this Society. Our esteemed friend Mr M'Farlane belongs to the class of anti-geologists alluded to by Hugh Miller in "The Testimony of the Rocks;" and at page 397 of that work, the views of Mr M'Farlane are stated at considerable length, and are opposed by the facts of science, and also, perhaps somewhat unnecessarily, by the shafts of ridicule. It is not likely that Mr M'Farlane will gain many converts to his views on cosmogony from amongst the members of this Society, but he deserves our best thanks for his earnest and well-meant zeal in urging what he believes to be of the highest importance to the cause of truth and science.

II. *On the Irregularities of the Earth's Surface, and the Probable Mean Line of the Terraqueous Circumference.* By WILLIAM RHIND, Esq.

The periphery of the earth's surface consists of land and water at different levels, and the question may be suggested —whether is the surface of the ocean, or the mean level of the land, the true line of the earth's circumference, or, in other words, what is really the medium line of the irregularities of the earth's surface?

Though our knowledge of the sea-bottom is yet very limited, yet the investigations of recent years have added very considerably to this knowledge. The soundings of Sir James Ross in various parts of the ocean have disclosed interesting facts concerning its depth and temperature; these were followed by other British and American navigators, and the whole has been collected and published by the labours of Lieutenant Maury. From these and other researches, we find that the earth's superficies, both under the ocean and above it, presents an exceedingly irregular form, consisting of a series of elevations and depressions. On this irregular surface are diffused the waters of the ocean, spreading over and concealing from view more than two-thirds of the superficies, while the higher portions only, amounting to somewhat less than one-third, appear as dry land. The greater amount of soundings have been made in the Atlantic Ocean, and thus we have become better acquainted with its bottom than with that of the other oceans of the globe. A section from the Cape de Verd Islands, on the coast of Africa, to the mainland of South America, gives soundings of 17,000 and 22,800 feet. A section south of Newfoundland gives the greatest depth yet authentically ascertained as 27,180 feet. Further north, in the line of the late electric telegraph from Ireland to Newfoundland, the depths are 10,000, 11,000, and 12,000 feet. On taking a mean of twenty-seven soundings in various parts of the Atlantic, and rejecting a few doubtful ones, the mean depth of this ocean is indicated as 13,100 feet, or two and a half miles. Soundings in the Pacific, also, indicate

depths equal to the above in some positions, but the probability is that the central portions of that vast ocean, occupied by extensive coral reefs and innumerable islands, are of less depth than the mean of the Atlantic. The Mediterranean exhibits depths of 5000, 10,000, and south-west of Malta, 15,000 feet. The North Sea is shallow. On the whole, an approximate mean of the ocean depth may be estimated at two miles. Now, if we turn to the elevations of dry land, we find that a few mountain peaks attain heights equal, if not surpassing, the extreme depressions of the ocean,—in the Andes, 20,000 to 23,000 feet; in the Himalaya, Kin-Kinchunga, 28,000 feet; and Mount Everest, 29,000 feet. But the mean elevation of land is far inferior to the mean depth of ocean. According to Humboldt's calculations, were the whole surfaces of the continents of Asia, America, and Europe reduced to a uniform level, that mean level would stand at only 1000 feet above the sea level. From recent explorations of Africa, by Beke, Livingstone, and Speke, we find that extensive table-lands of 2000 to 3000 feet occupy the central portions. Some mountain peaks attain a height of 20,000 feet, and these, contrasted with the vast level deserts and low-lying river valleys and shores, would seem to indicate not a higher general level for Africa than that of the other continents. Similar recent explorations in Australia also indicate that that region may be also comprehended in a general mean elevation of 1000 feet of the whole dry land of the globe. We thus find that while the extremes of elevation of land about equal the extreme depressions of ocean, the mean depth of the ocean is 10,560 feet, or two miles, while the mean elevation of land is only 1000 feet. If we add these two means together, we have 11,560 feet as the mean of the irregularities of the earth's surface. Now it will be perceived that the ocean surface does not stand at the mean or half section of these irregularities, but on the contrary stands at the base of the dry land, or 1000 feet from its mean upper surface, and nearly 5000 feet above the line *bb* (see woodcut), which we have indicated as the mean of the earth's irregularities; for if the ocean were entirely awanting, the line would in reality be

the mean line of the earth's irregularities, and consequently the true circumference and line of gravity regulating the invariable diurnal revolution of the spheroid. Or, to extend the expression of the formula used by Humboldt, if the whole irregularities of the earth's surface were levelled down to one uniformity, the earth's circumference line would occupy a position, *bb*, nearly 5000 feet below the present ocean level. But as water is only about half the specific gravity of the materials composing the superficial strata of the earth, twice the volume of water is thus necessary to fill up the depressions and to bring about that equilibrium which is required. In looking, therefore, at a section of the earth's surface, con-

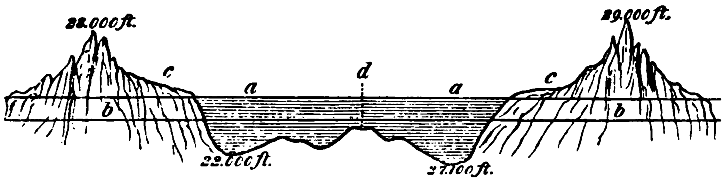


Diagram shewing the relations of Land and Water on the Surface of the Earth.

aa, present surface of ocean; *bb*, mean line of earth's irregularities; *cc*, mean of elevation of land, 1000 feet; *dd*, mean depth of ocean, 10,360 feet.

structed according to the above measurements (see woodcut), it will at once be seen how small a proportion the mean elevation of land bears to the mean depth of the ocean—that while the extremes of both are nearly equal, the extreme elevation of mountains equalling the extreme depressions of ocean, the ocean surface occupies a level half-way between these extremes, and thus becomes the actual line of circumference. But then its surface is thus raised from the true central line of the earth's inequalities, in consequence of the less relative specific gravity which water bears to the superficial strata of the earth's crust. In this approximate view which I have attempted to suggest, I have left out of view the zone of atmospheric air; which, however, must form an element in any rigid calculation of the true line of circumference which regulates the diurnal revolution of the earth.

There would appear also to be this general arrangement in the seeming irregularities of the earth's surface, that the depressions of the sea-bottoms accompany and compensate the elevations of continents, and thus preserve the due equilibrium of the rotating spheroid. Thus the Atlantic is a great hollow basin between the elevated continents of Asia and Africa on the east and America on the west; while the deepest portions of the Pacific are on the west side of the American continent, and its central portions are comparatively shallow. Even in inland seas, the depths of the Mediterranean, ranging from 5000 to 15,000 feet, correspond with the elevations of Mont Blanc and the Alpine range, while the shallow Baltic and North Sea are surrounded by lands of no great elevation. We thus find in the great operations of nature that adaptation of means to ends which pervades the whole works of creation, and which are as perfect in the arrangements of the mechanism of worlds as in the minutest objects which exist on their surfaces.

III. A *Wernerian Examination of the Six Points of Pluto-Huttonism.* By Professor W. MACDONALD, St Andrews.

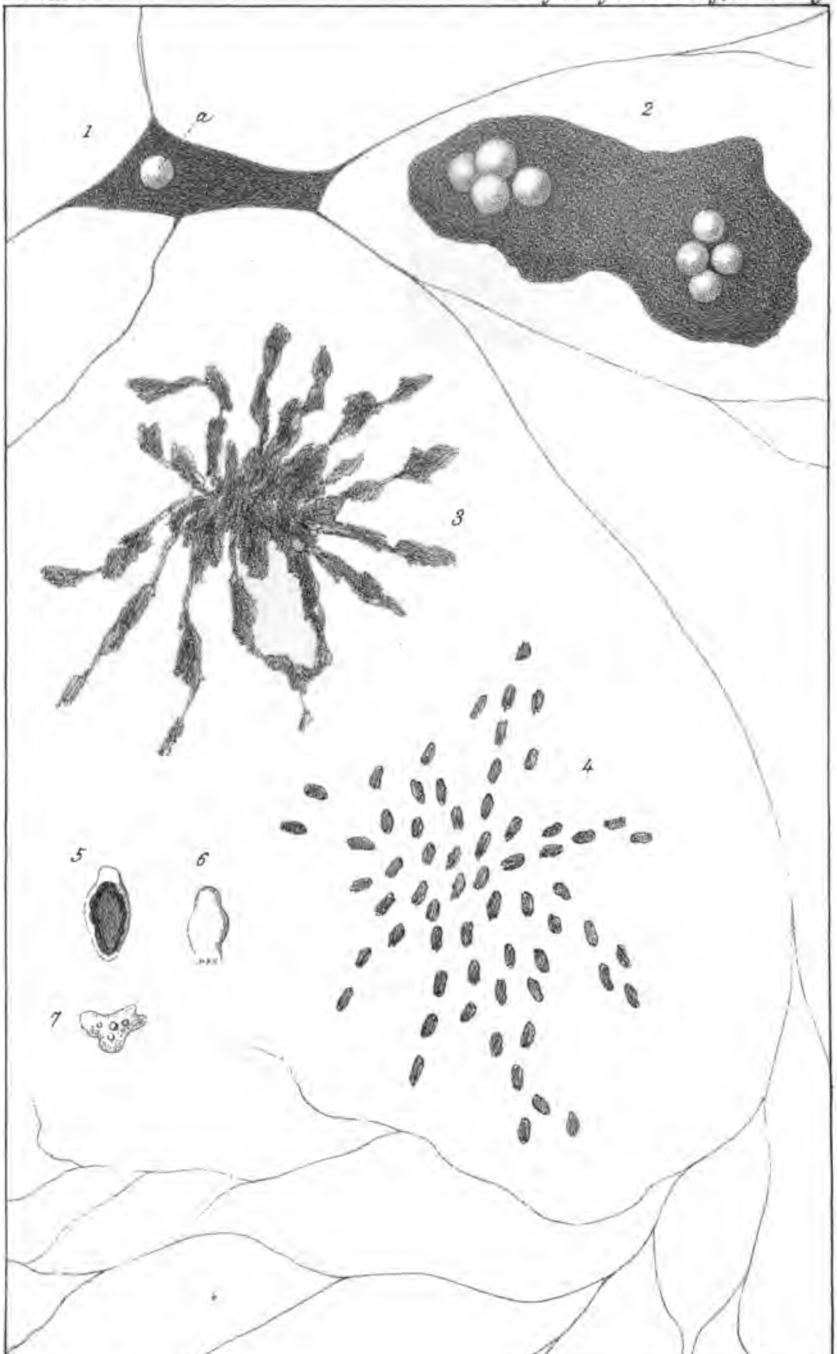
Wednesday, 23d March 1864.—DAVID PAGE, Esq., President, in the Chair.

Andrew Davidson, Esq., physician and surgeon, Antananarivo, Madagascar, was balloted for, and elected a Non-Resident Member of the Society.

The following Donations were laid on the table, and thanks voted to the Donors:—

1. (1.) A Synopsis of the Carboniferous Limestone Fossils of Ireland. (2.) A Synopsis of the Silurian Fossils of Ireland.—From Richard Griffith, F.G.S. 2 Transactions of the Botanical Society, Vol. VII., Part 3, 1863.—From the Society. 3. Canadian Journal of Industry, Science, and Art. New Series, Nos. 46, 47. July to September 1863.—From the Canadian Institute. 4. Rules for Zoological Nomenclature. By the late Hugh E. Strickland, M.A., F.R.S. Authorised by Section D. of British Association at Manchester, 1842. Reprinted by requisition of Section D. at Newcastle, 1863. Two Copies.—From Sir William Jardine. 5. Otago Provincial Government Gazette, Vol. VI., No. 274. Geological Expedition to the West Coast of Otago, New Zealand, 1863.—From the Agent of the Provincial Government of Otago, Edinburgh.

PLATE II.



T. Strethill Wright, delᵗ W. H. McFarlane, Lithʳ Edinʳ

Bodeeria Turneri.

The following Communications were read:—

I. *Observations on British Zoophytes and Protozoa*—1. *On the Structure and Reproduction of* Boderia Turneri, *a new Rhizopod ;* 2. *On the Prehensile Apparatus and Sting-Cells of* Cydippe; 3. *On the Stem-Canals of* Tubularia indivisa. By T. STRETHILL WRIGHT, M D.

1. *On the Structure and Reproduction of* Boderia Turneri.*
(Plate II.)

EXPLANATION OF PLATE.

Fig. 1. *Boderia Turneri ; a,* ovum.

Fig 2. Large specimen of *B. Turneri,* with two groups of ova. Probably consisting of two animals in conjugation.

Fig. 3. *B. Turneri,* having ruptured its test and spread itself into a ragged mass previous to depositing the naviculoid bodies.

Fig. 4. Group of naviculoid bodies.

Figs. 5 and 6. Naviculoid body previous to and after the discharge of the amœba.

Fig. 7. Amœboid germ of *B. Turneri.*

In July 1863 a number of shells and zoophytes were brought in by my son, Mr Strethill Harry Wright, which were dredged in the neighbourhood of Inchkeith. They were placed in vessels of sea-water, and in a few days a number of the rhizopods, to which I have given the name of *Boderia,* appeared on the sides of the glass. The animal (fig. 1) consists of a simple mass of deep brown, sometimes orange, sarcode, enclosed in a very delicate membranous envelope, from openings in which it protrudes long pseudopodial branches, generally three or four in number, but sometimes more numerous, especially in the larger specimens. Its shape is variable, sometimes presenting the appearance of a conical mass with pseudopodia spreading over the glass to which its base adheres; at other times, that of an extended plate with many angles, from each of which protrudes a pseudopodial branch. In the majority of individuals a single large nucleus (fig. 1, *a*) only appears, spherical and transparent, but in others three or four such bodies occur

* This animal was first named Turneria, after W. Turner, M.B., who kindly assisted me in the examination of it; but as "Turneria" was found to be preoccupied, "Boderia," one of the ancient names of the Firth of Forth, was adopted.

grouped together; while in others again, as many as nine or ten are detected in two clusters (fig. 2); but in these cases I am disposed to think that the individual is composed of two animals in a state of conjugation, as it is always elongated and slightly constructed between the masses of nuclei. These animals, from their large size (from $\frac{1}{8}$th to $\frac{1}{4}$th of an inch in diameter), can be readily transferred to a flat cell under the microscope, when the excessively rapid movement of the sarcode affords a very interesting and astonishing spectacle. Each of the great pseudopodia consists of a number of streams, some rapidly coursing outwards, others passing inwards more slowly, and dragging along masses of diatoms, minute alga, and infusoria. Even in the most minute branches of the periphery a double movement, in opposite directions, is clearly visible under high amplification. In fact, the whole organism reminds one of a great central railway station, the meeting-point of numerous converging lines, to which an unceasing flow of traffic is ever tending. A rude touch, as with a needle point, to the animal itself, has the effect of arresting the outward movement, and of determining the whole flow rapidly to the centre.

An explanation of the movements of the pseudopodia is extremely difficult; and indeed the same may be said of the nature of the pseudopodia and whole structure of the rhizopod itself. We find it difficult to believe that a mere mass of gelatinous slime, apparently homogeneous, can determine such purpose-like and varied movements through the wide-spread and ever varying extension of its network, and can instantly arrest or alter these movements at will, or from the effect of external stimulus. Accordingly, Reichert has dissented from the sarcode theory, first promulgated by Dujardin and strongly insisted on by Schultze, and is of opinion that the pseudopodia consists of bundles of excessively fine filaments—so fine "that a perceptible thickening scarcely appears when several filaments come together, or when the magnifying power is raised from 450 to 700 diameters." He considers "that when the animal first extends its pseudopodia the more simple radiate arrangement predominates; soon afterwards the apparent ramifications

commence, and become constantly more numerous. The branches, after issuing or becoming free, easily reach their neighbouring filaments, apply themselves to these, and then appear as anastomoses. By the multiplication of such apparent anastomoses those reticulated figures are produced which are known under the name of the Sarcode net. At the same time bridge-like unions, and membrane-like structures, between the filaments become visible." "Favourable conditions for the multiplicity of forms, and for their ready and often imperceptible change, are also furnished by the extraordinary number of the filaments and their flexibility." And he further states, that "the appearance produced by these readily moveable parts in the protean system of filaments, as if a moveable substance assumed any form or spread and poured itself into any shape, is an illusion which is set up especially by the circumstance that individual minute parts, which are readily displaceable throughout, can never be distinguished at their points of contact."

No doubt the theory of Reichert is exceedingly ingenious and plausible, but it appears to me to be especially open to two objections. *1st*, If the infinitely fine fibres of Reichert had such an amount of cohesion as to enable them to form bundles and membranes of apparently homogeneous structure, such an amount of cohesion would prevent the rapid motion of the fibres on each other in opposite directions. *2dly*, We see the same fibrous arrangement of the protoplasm in the interior of the vegetable and animal cell. In the cell of Anacharis, for instance, when the circulation has been arrested, we frequently observe the protoplasm distributed as a more or less perfect mesh-work over the whole cell. After a time of rest, movements commence in the threads in no respect differing from those of the pseudopodia of the rhizopod, and the protoplasm creeps to the borders of the cell where the circulation commences. So in the cells of the tentacles of Coryne, the protoplasm assumes a similar thread-like and reticulated arrangement; in fact, that each cell contains an imprisoned rhizopod. Perhaps the Society may remember that I sometime ago showed a true rhizopodic structure to exist in the pigment corpuscle of the fish, which

consists of a moving protoplasm, branching and coalescing like the pseudopodia of the animal now under consideration. Now we cannot suppose that the protoplasm of the Anacharis, the Coryne, or the pigment corpuscle is composed of cohering fibres.

It is true we are at a loss to understand the phenomena of the movements of the sarcode; indeed, we can scarcely form any conception of a power capable of producing such movements, or of its mode of action; but we are equally at fault with regard to the movements of muscular fibre, or those of cilia. It is probable that in all these cases the movements are due to modifications of the molecular attraction of the tissue, caused by a corresponding modification of the vital force, and analogous to the modification in the cohesive and molecular forces effected in organic matter by alterations of electro-polarity. Thus, if a globule of mercury be rendered positive by contact with the anode of a voltaic arrangement in a solution of hydrocloric acid, its coerced affinity for this solution will overcome the attraction of cohesion between its own molecules, and it may be drawn out in threads, which will remain permanent while connected with the battery; the moment, however, the mercury is released from its forced polarity, by touching it with the kathode of the battery, all the threads of the metal are drawn in with convulsive violence, and it assumes its globular state, being repelled by the acid which before attracted it, and resuming its cohesive form. Another very beautiful instance of movements produced by the modification of cohesive or capillary attraction is shown in an experiment which I have lately perfected. A sheet of mica is laid on a moistened plate of brass; a drop of sulphuric acid is gently deposited on the mica, and the brass and the drop connected with the extremities of a weak induction coil; as long as the machine is at rest the drop remains globular and quiet, but the moment the electric current is set in motion, the drop begins to put forth *pseudopodia*, as it were, and spreads itself over the mica in a beautifully branched figure, exactly resembling the pigment corpuscle of the fish and the movements of its protoplasm.

In citing these instances, I do not mean to infer that electricity is engaged in the vital movements of the sarcode, but merely to show how movements resembling them can be closely imitated by processes connected with inorganic matters, the rationale of which we have no difficulty in explaining.

Reproduction.—In a former paper read before this Society, I communicated the discovery of true ova, with germinal vesicle and spot, in a rhizopod Truncatalina, and considered that, as it was impossible that bodies of so great a size could escape from the openings of the shell, it was probable that in these genera a " polymorphic development took place, similar to that described by Carter in *Amœba verrucosa*, and such also as seems to occur in Gregarina, either with or without a previous process of conjugation. In Boderia such a development plainly occurs. In specimens under observation these nuclei or ova were seen to disappear; and some hours afterwards the sarcode of the animal burst or issued from its envelope, and spread itself in ragged masses (fig. 3) over the glass, connected by drawn-out threads. In the course of a few hours later the sarcode became entirely dissipated, leaving a swarm of naviculoid bodies (fig. 4) attached to the glass, from each of which, in a day or two, issued a minute nucleated and amœboid mass (fig. 7) of sarcode. These little amœbas existed for many weeks as a closely aggregated band of many inches in length near the surface of the water, without assuming a test, or putting forth pseudopodia; nor were the latter processes ever observed, although minute specimens gradually made their appearance in the vessel in considerable numbers. I am disposed to think that the change from the naked amœboid to the incysted rhizopodic form in this animal constitutes a distinct stage in its development. We here have the life history of the Rhizopoda and Gregarinidæ brought in very close analogy to each other:—Thus, in Gregarina we have a conjugating process, followed by an encysting of the animals, or the encysting may take place in a single Gregarina; next, " certain globular vesicles appear in the cyst, and these become metamorphosed into ' pseudo-naviculæ.'" The cyst

of the single or conjugated Gregarina bursts, and the pseudo-naviculæ escaping, presently give vent to amœbiform bodies, which are at length developed into Gregarina. The consideration yet remains ,—must the so-called nucleus be considered as an ovary or a true ovum? I am disposed to view it as the latter, on account of the existence of the single nucleolus and spot within it, and to consider the so-called polymorphic development as comparable to the fissure stage in the ova of higher animasl, but which, in the case of the unicellular Gregarina and Rhizopod, becomes a final stage of egg development; and I would hint, that in the higher animals the fissured elements of the ovum remain together to form a multicellular organism, while in these lower ones the same elements finally separate at a corresponding stage, to form a swarm of unicellular animals.

2. *On the Sting-Cells of* Cydippe.

In Agassiz's contribution to the "Natural History of the United States," vol. iii. p. 238, a description is contained of the thread-cells of Cydippe, which purports to be a more correct account than that given by Gegenbaur and myself. The author states the cell contains a spiral thread, as stated by us, but he also states that the granular matter which we had described as within the cell is really without it, and consists of a close layer of granules investing the whole wall of the cell. Now it is very evident that, in case the cell were covered with a simple layer of granules, it would be impossible that it could retain its hold of the wall of the tentacle, and would also differ from the mode of attachment of the thread-cells of all other animals, which, however they may vary in structure, are always buried in the ectoderm of the structure in which they are situated. On a re-examination of these bodies, I found that Agassiz was correct in his opinion as to the granular matters being situated in the exterior of the cell, but mistaken in his opinion that it merely consisted of a layer of granules attached to the cell. The whole tentacle is, in fact, covered with an ectoderm of sarcode, which, like that of Actinophrys,

contains numerous granules, and this ectoderm is continued over the cells, they, like the thread-cells of other animals, being buried within it. A still more remarkable error is committed by the learned author in describing the cells as being able to protrude their lassoes or threads through an opening in the summit of the cell and again retracting them, and further, in imagining that the threads are instruments of prehension. A very careful examination has assured me that what he has mistaken for protruded threads are indeed prolongations of the sarcode of the ectoderm analogous to the processes of the Rhizopods, and to similar processes which are found over the thread-cells of other animals. In Cydippe, however, they more readily retracted and extended than in the other cases.

3. *On the Stem-Canals of* Tubularia indivisa.

In the fourth volume of Agassiz's "Contributions to the Natural History of the United States," the author has noticed a paper of mine on the stem-canals of this zoophyte, which I have represented of *equal size*, and running along the stem within the ectoderm. Having described the canals in the stem of *Tubularia Couthouyi*, and found one of these canals larger than the others, he remarks, "We find the large and the small channels also in a very closely allied species, the *Tubularia indivisa* of Europe, sent to us by Sars from the coast of Norway; and if the observations of Dr Wright were made upon the same species, then his discovery, although very interesting, is a partial one." I have again repeatedly examined the stem of Tubularia, and find that although one or several enlarged tubes *occasionally* exist, it is by no means of constant or frequent occurrence. In this zoophyte there is no ground for stating that it exists and constitutes, according to the theory of Agassiz, the broad chyliferous cavity of the stem.

II. *On the Geographical Distribution of the Marine Invertebrata in past time, considered in relation to the Doctrine of the Secular Cooling of the Earth.* By ANDREW TAYLOR, Esq.

The doctrine of the secular cooling of the earth has again been prominently brought before the scientific public, by two ingenious calculations regarding the time required for such a phenomenon to take place.

Professor Haughton of Dublin demands 1018 millions of years for the earth to cool down from 212° F. to 122° F.; the latter temperature being supposed the one at which the waters became habitable. He moreover demands the farther period of 1280 millions of years for the cooling from 122° F. to 77° F.; a period comprising the whole time from the first appearance of life in the earth to the latest Eocene epoch. If such decided physical changes have occurred during the period from the appearance of life on the globe to the dawn of the present creation, they must have influenced very decidedly the succession and distribution of life in the geologic eras.

If such calculations can be ranked amongst the ascertained facts of science, biological speculations founded on them will likewise pass from hypothetical probabilities into scientific deductions.

That they are far from this, however, may be seen by alluding to Professor William Thomson's calculations on this subject: he fixes the time required for the whole period of the earth's crust from a state of fusion to its present condition, at 98 millions of years, and therefore allows only 100 millions of years for all speculations regarding the earth in its solid state. Experimental data are adduced in support of his assertions. Such are the widely discrepant results attained by two eminent savans. Do they not throw great uncertainty on the whole subject?

Notwithstanding, it may not be unphilosophical to investigate the appearance and distribution of life in geologic times, on the assumption that this hypothesis is an ascertained physical fact.

Such an inquiry will best be conducted by the examination of the marine fossils, particularly of the oldest beds. These forms of life are well known to have predominated throughout most of the geologic cycles. Indeed, only in the very latest epochs do terrestrial animals prevail, either numerically, or in geographical distribution, in anything like the present fashion. Now, though celebrated physicists have proved the amount of heat given off from the solid crust of the globe, in cooling down from incandescence, to have been so inconsiderable, even through enormous cycles of time such as have been hinted at, as not to affect the condition of organic life on the land, their calculations do not touch on the physical conditions that might have influenced marine life in geologic times. Indeed, recent physical data appear to assert that this variety of life might have been seriously affected by physical influences. Professor Frankland, in advancing his recent theory " on the cause of the phenomena of the glacial epoch," has experimentally shown that water cools very much more slowly than a solid body; indeed, nearly twice as slowly. Now, if the temperature of the ocean has been diminished, even in a very slight degree, throughout such enormous cycles of time as the calculations first referred to hint at, very decided biological changes must, in consequence, have occurred. An investigation in detail, more especially of the appearance of the marine invertebrata, would assist us in ascertaining if such changes have occurred. In connection with this, the present distribution of marine animals might be carefully investigated, in relation to the effect of heat on oceanic life.

In calling the attention of naturalists to this line of inquiry, the author is aware that it may be shaken to its foundation by the investigations of another school of physicists, who deny the doctrine of the secular cooling of our globe altogether. Yet this apparent uncertainty as to the investigation ending in the elucidation of exact truth should not deter us from it.

III. *A List of Land and Freshwater Shells found in the County of Caithness.* By CHARLES WILLIAM PEACH, Esq., Wick.

In 1861 Mr A. G. More, of Bembridge, in the Isle of Wight, informed me that he was collecting materials for illustrating the British Land and Freshwater Mollusca, according to the method employed by Mr H. C. Watson, in his "Cybele Britannica," and asking for information about Caithness, it being included in his Province 17. He then was "only able to enter a single shell, *Alasmodon margaratifera.*" Although I had then paid very little attention to the subject, I had picked up a few specimens whenever they came in my way, and put them away for those who might want them. At once I turned over my hoards and made out a list. Not contented with merely sending this, I forwarded many of the shells, and thus, instead of "only *one*," he had *seventeen* to place in his "Province 17." I have continued to gather, and now, as may be seen by the accompanying list, we have *thirty* species. In order that I might speak with certainty, I have asked authorities to examine all the specimens for me. Foremost, Mr J. G. Jeffreys, of London, the author of the valuable work the "British Conchology," vol. i., 1862, used to name and arrange the list by, has seen the shells; the Rev. Mr Norman, the slugs. Mr More has also seen many of the shells. I feel under great obligations for their prompt and kind assistance. With the exception of *Helix ericetorum*, I have found all in the parish of Wick; many of them have been found as well in different parts of the county. My examination has not been a very strict one, nor very extended, for a great part of the county I have never been in, especially inland, where additions may be most expected. The last summer I added two species of freshwater shells to the list, and as well confirmed three or four others of which I had before only doubtful specimens.

I have hopes of assistance from others, for Miss Gunn of Reisgill, Mr Shearer of Ulbster, and Mr Anderson, of the "John o'Groat Journal" here, have entered on the pursuit successfully; and although at present they have added no

new species, they have greatly assisted in extending localities, and from their quick observation I have great hopes.

At present, until more facts have been collected, it is not desirable to enter on a comparison of this district with others, nor anything else beyond giving the numbers stated in three local lists which I have. First, Mr Alder's "Catalogue of Northumberland and Durham;" that of Aberdeen, by the late Professor Macgillivray, in the work on "Dee Side;" and that of the "Province of Moray," by the Rev. Dr Gordon, published in the "Zoologist."

Northumberland and Durham,	80 species.
Aberdeen, ...	53 „
Province of Moray, . .	46 „
Caithness, ...	30 „

I would here remark, that when the well-known fact of the diminution of the pulmonifera as we proceed north is taken into consideration, with the little examination made, and the small area included in our list—viz., Caithness only—there is little cause for either surprise or dissatisfaction, and it only requires more eyes and willing hands of the lovers of Carnabia to be set in motion, to increase the number for a supplementary list. When this is the case, I hope to return to the subject. For the present be pleased to accept of this as an instalment only.

N.B.—Those marked with an asterisk (*) have also been found in the marls of Caithness.

* *Sphærium corneum*, Brickigoe, River of Wick, &c.

Pisidium nitidum, River of Wick, and Loch of Sarclet.

Unio margaratifer, River of Wick—rather plentiful.

* *Valvata piscinalis*, Loch of Brickigo, and River of Wick.

* *Planorbis nautilus*, Reiss, and near the Mill of Thrumster.

* *P. albus*, very rare, Loch of Brickigo.

P. glaber, Reiss, and near the Mill of Thrumster. Mr Jeffreys says:—" These are finer than usual, indeed very near as large as some Mr Bridgman found near Norwich.

Planorbis spirobis, same localities as the last. Jeffreys records it as " from the Moray Firth district to the Channel Islands."

* *P. contortus*, River of Wick and Loch of Brickigo.

* *Linnæa pereger*, Wick, Ulbster, &c. &c.

L. truncatulus, Southhead, Wick, &c.

Ancylus fluviatilis, plentiful in many localities. Jeffreys says—

"Everywhere from Aberdeenshire to the Channel Isles." I got this at Reiss, *fine*, under similar circumstances that Mr Jeffreys did at Swansea,—"in an old quarry into which no stream flows."

Arion ater, in many localities.

A. hortensis, a pest especially in gardens

Limax flavus, several places.

L. agrestis, another pest in fields, &c. I got also a very dark one, hitherto considered a variety of the above, now *L. parvulus* of Normand, a French conchologist.

* *Succinea elegans*, in several places, but far from common.

Vitrina pellucida, in many localities.

Zonites cellarius, as the above.

Z. alliarius, generally diffused, has a strong garlic-like smell.

Z. nitidulus, Wick, rare; Jeffrey's range, "Moray Firth district to Guernsey."

Z. crystallinus, Whaligo, Wick, and Freswick; Jeffrey's range as above.

Helix nemoralis, variety *hortensis*. In several localities, generally on the sea-coast.

Helix arbustorum, same localities.

H. ericitorum. On sandbanks between Castlehill and Murkle, and on the Links at Reay. Jeffreys says, "Apparently not ranging farther north than the Hebrides."

Helix rotundata, several places.

Pupa umbilicata, as the above.

Clausilia rugosa, in the cliffs on the sea-coast, near Girnigo Castle, Southhead Wick, and old limekiln near Hemprigs.

Cochlicopa lubrica, in several places.

So far the list for Caithness. I am, however, desirous of adding two shells found by me in Sutherlandshire, believing they are of sufficient interest to be noticed here.

Helix rupestris, on limestone rocks at Durness, in August 1857. Rare. Fleming mentions it as a Scottish species.

Bulimus acutus, sandhills at Auldshore Beg, near Cape Wrath, July 1861, and at Durness, August 1857, associated with *Helix ericetorum*. It is strange not to find the *B. acutus* with the latter shell in Caithness. Dr Gordon says—"Collected in Caithness, and found in rather a suspicious locality—on a mantelpiece."

It is the only authority he has for including it in his list; he however says, "It is not without some hesitation that this pretty species is here included," a caution I fully agree with, having sought for it attentively, and so far in vain.

IV. *On the Homology of the Vertebrate Cranium.* By Professor MACDONALD, St Andrews.

Wednesday, 27th April 1864.—WILLIAM TURNER, Esq., M.B., President, in the Chair.

David Young, Esq., Medical Missionary Dispensary, Cowgate, was balloted for, and elected a non-resident member of the Society.

The Report of the Treasurer, Mr G. Logan, W.S., was read and approved.

The usual Committees were appointed, for prosecuting special investigations during the summer recess.

The following Donations were laid on the table, and thanks voted to the Donors:—

1. Proceedings of the Academy of Natural Sciences of Philadelphia. 1863.—From the Academy. 2. Proceedings of the Literary and Philosophical Society of Liverpool, No. 47, 1862-63.—From the Society. 3. Proceedings of the Royal Society, Nos. 57 61.—From the Society. 4. Canadian Journal of Industry, Science, and Art. New Series. Nos. 48, 49. Nov. 1863, Jan. 1864.—From the Canadian Institute. 5. Jahrbuch der Kaiserlich—Königlichen Geologishen Reichsanstalt, 1863. XIII. Band, Nro. 3, Juli, August, September.—From the I. R. Geological Institute of Austria. 6. Dublin Medical Press. Second Series. Vol. VIII. No. 199.—From the Publisher. 7. Journal of the Proceedings of the Linnean Society. A complete series from March 1856 to October 1863.—From the Society.

The following Communications were read:—

I. *On the Origin of Granite.* By WM. STEVENSON, Esq., Dunse. Communicated by GEORGE LOGAN, Esq., W.S.

The object of this paper is not to discuss the various opinions which have been held relative to the origin of granite,—opinions with which the Members of this Society must all be familiar, but simply to lay down a proposition embodying the author's views on the subject,—following this up by references to the phenomena exhibited in certain localities, so that all who feel interested may go to nature, examine and judge for themselves.

PROPOSITION.—*Granite is the result of the fusion (total or partial), by means of* MOLTEN FELSPAR, *of rocks adjacent to the place of eruption.*

It may be of any geological age, but is in general found

to be most typically developed in association with the oldest sedimentary rocks.

The following are a few notes (nearly as taken upon the spot) of the appearance presented at some junctions of granite with stratified rocks. The localities being, in general, of easy access, it is hoped that in the course of the ensuing summer, many Members of the Royal Physical Society may be induced to visit one or more of them, especially as they all have the additional recommendation of grand or beautiful scenery.

Localities referred to.

1. *Glencoe.*—Beyond the bridge across the Cona (above Glencoe village), mica slate, approaching in character to hornblende schist, dips W.S.W. about 70°. Above this, mica slate interstratified with quartz rock continues for some distance up the glen. About a mile up, and not far below the place where the glen takes an easterly turn, a mass of extremely hard and tenacious porphyry appears among the schists. Its cleavage planes are stratiform, and dip E.S.E. about 50°. This appears to be a root vein from the mass in the interior of the mountain on the left. A little further up (almost at the bend), strata of quartose mica slate dip W. by N. about 50°. The high mountain on the left is formed of schists and quartz rock, highly metamorphic, and heaved up and invaded by the porphyry. A fine junction of the latter with the schists is seen near this place (a little below Clachich), and may be traced for a considerable distance. The line of junction is uneven, but ranges nearly N.N.E to S.S.W. The metamorphism of the schists here is extreme. They resemble hornblende schists, or rather the highly altered dark-coloured silurian strata of some parts of the Lammermuirs, *e.g.*, Cockburnlaw, &c. Some very distinct vertical rectangular cleavages are here seen in the porphyry, ranging N.N.W. by E.N.E. The rock which exhibits this structure is stratiform, the beds being three or four feet thick, and dipping about N.E. by N. 30° to 40°. On the upper side of this porphyry, the schists again appear, dipping W.N.W. 50° to 60°, much altered. At

Clachich, several beds of highly metamorphic quartz rock are seen, with the same dip. Porphyry (red felspar) is very frequent, traversing the schists in conformable veins, or intersecting them at various angles. Within the glen proper, a beautiful massive granite, composed of white quartz, red felspar, and black mica, is seen in the bed of the Cona. Its divisional planes are vertical, W.N.W. to E.S.E. It here encloses portions of what seem to be fragments of schist melted down. These are of a dark hue, approaching black. A few yards further up, the granite is divided by cross fissures, the divisional planes here being W.N.W. by N.N.E. Just above this place, the granite resembles a trap tuff. It contains fragments of schists and quartz rock, much altered, in great abundance. The *fusion* here has not, however, been complete. Above this, the transition of the schists into the granite is well seen. The strata have been melted *in situ*, retaining their planes of stratification as principal cleavages. Where the fusion has been imperfect, the result is a kind of *gneiss*. Some very beautiful beds of granitoidal schist are here seen. The adjoining strata consist of laminæ of clay and mica slates, alternating with very thin layers of granular quartz. Near the granite and porphyry, where the metamorphism becomes extreme, flesh-coloured felspar is added, chiefly between the slaty and quartzose laminæ. It appears to have been introduced into the schists rather by a process of molecular transference whilst the beds were softened by the intense heat of the adjacent molten matter, than by simple injection in a melted state into open crevices between the laminæ. At this interesting spot, within the space of a few yards, are to be seen granite, porphyry, quartz rock, micaceous clay slate, a sort of hornblende schist, gneiss (the result of the addition of felspar to the quartzose schists above described), and a great variety of mixtures of all these, the result of their total or partial fusion. The porphyry here is of the common flesh-red colour, but is harder than usual, owing to its containing a considerable admixture of quartz, evidently derived from the quartzoso strata through which it has been erupted. It also contains a little black mica; and, in fact, might technically be with propriety termed a

fine-grained granite. It is indeed a sort of link between granite and porphyry. Some of the coarser grained arenaceo-argillaceous strata seen at this place also show a transition to a kind of syenitic granite,—a fine-grained mixture of quartz, felspar, and horneblende, with or without mica. The appearances at the junctions of the granite and greywacke of Cockburnlaw, in Berwickshire, are exactly similar to those so beautifully exhibited at this part of Glencoe. Further up the glen, highly metamorphic rocks occur, blending the characters of the porphyry and schistose rocks in endless variety. The strata and laminæ are distinctly marked, vertical, with a N.N.E. strike. These consist of quartz, compact felspar, and micaceous hornblende, being technically *gneiss*. Many rocks in Glencoe which have been termed porphyries are evidently nothing more than highly metamorphic schists, generally dark coloured, frequently retaining most unequivocally their original planes of stratification, and containing less or more felspar absorbed from the igneous masses which caused their metamorphism. The whole glen, as well as the wild and rugged district between it and Ben Nevis, are of the highest geological interest, especially as bearing upon the subject of this paper and igneous metamorphism in general. Of the wondrous scenery of this part of Scotland it is unnecessary to speak.

2. *Ben Nevis.*—At Nevis bridge, and across the level mouth of the glen to where the ascent begins, metamorphic schists, similar to those seen in Glencoe, dip S.S.E. 50° and upwards. Immediately on commencing the ascent on the west side, granite appears, the faces of the rock having a direction nearly N.N.E. to S.S.W. At the top of the first ascent (about 2500 feet or more), the granite is extensively exposed, massive and divided by fissures running E.N.E. to W.S.W., which look suspiciously like traces of planes of stratification. These are crossed by a few others ranging N. by E. to S. by W. This granite appears to be a compound formed by the fusion, or partial fusion, of the stratified rocks by the porphyry. The coincidence in the direction of its principal divisional planes with the strike of the schists at the mouth of the glen, seems much in favour of

this view, and its composition also agrees with it. Abundance of red porphyry may be seen under the hard, dark, grey rock, which has been so termed, and which constitutes the upper part of the mountain. The junction of these, doubtless, exhibits many interesting appearances, which the heavy talus of fragments and the thickly falling snow prevented my seeing on the occasion of my visit.

3. *Morven.*—The district opposite Port Appin, and lying southward of Kingairloch, consists chiefly of granite, of which there are many varieties. At the base of the mountains, close upon the shore, the felspar predominates to the almost entire exclusion of the other constituents. At a greater altitude, the granite is more normal in its character, but mica is, upon the whole, rather rare. The granites are fissured in all directions, with no apparent regularity, but lines running N.N.E. to S.S.W. are rather more frequent than the others.

4. *Loch Etive.*—On the shores of the loch, N.E. of Bunawe, the base of Cruachan presents a most extraordinary combination of stratified and unstratified rocks. The latter consist of granites of every variety,—felspar porphyries, with acicular crystals of hornblende; compact felspar; a hard, dark-coloured rock, like that which forms the upper portion of Ben Nevis, &c. &c. The strata consist of hornblendic, chloritic, and quartzose schists, all metamorphic in the extreme, nowhere seen in large quantity, but broken up and imbedded in the granite. For a mile or two along the shore the granite is full of such detached masses. The transition from the latter to the former is in some instances gradual, and in others abrupt; but in every case the most complete junction has been effected, hand specimens, showing the *welding* (so to speak) of the two, being readily attainable. The granite here appears to have been formed in the same manner as that of Glencoe, viz., by the melting down of the more fusible schists, through the agency of the molten felspar; the less fusible portions, or those which happened to be involved in the cooler or exterior parts of the seething mass, having been only partially melted on the outside. Very little mica is seen either in the granites or schistose

rocks. Up the lake, a little beyond the mouth of the Awe, a felspar porphyry is seen under the granite, into which it appears to pass. This porphyry shows divisional planes ranging N. 30° W. At the bend of the loch, about two miles above Bunawe, the divisional planes of the granite are vertical, with a N.E. by N. strike, directed exactly to the valley between the Buachaile Etive mountains. This tract is one of the most instructive in Scotland in relation to the present subject.

5. *Arran.*—In ascending Goatfell from Brodick, at the mill-dam, where the junction of the granite and schists occurs, the latter are very hard and quartzose, commonly of a greenish grey colour, but sometimes dark, and resembling certain carboniferous shales. The granite sends veins into the schists, some of them only two inches wide. The substance of these veins is fine-grained, chiefly felspathic, and is firmly welded to the schists, though the line of demarcation is most distinct. The granites of Goatfell, Glen Rosa, Caistael Abhael, and of Arran generally, are chiefly composed of felspar, the quartz being in considerably smaller quantity, and the mica very deficient. In Glen Eis-na-bearadh, between two and three miles from Loch Ranza, a dyke of fine-grained granite appears in the bed of the stream. Further down, this dyke is seen to be connected with a mass of the same character, underlying the ordinary large-grained variety, and penetrating it in veins. The fine-grained granite is in some places almost wholly felspathic. Near the foot of the glen the junction of the granite with chloritic schists is well seen, the latter dipping under the former at angles of about 60°. The schists constitute the bulk of the conspicuous hill called Toirnaneidnoin, on the west side of which, at a great height, they are seen to be penetrated by granitic veins. Near the junction the schists are very hard, and shew alternating dark and light coloured laminæ, generally even, but sometimes curiously contorted. At the junction of the glen with Glen Chalmadail, the schists are vertical, with a W.N.W. to E.N.E. strike.

6. *Portsoy.*—A short way east of the town (upon the shore) the schistose rocks are nearly vertical, and consist

chiefly of quartz, with a little mica. A little to eastward, a beautiful, pure, flesh-red felspar has been erupted in three or four places. This, by combining with the micaceous schists, has become a splendid large-grained granite, containing many crystals of black tourmaline.

7. *Aberdeenshire.*—At Cove (about five miles S.E. from Aberdeen) the junction of the granite with the primary schists is beautifully shewn. The appearances here presented are highly interesting and instructive, and seem quite to confirm the proposition stated in the beginning of this paper. The schists here are generally very distinctly stratified and laminated, and dip to S.S.W. and S.W. at angles of 40° and upwards to near 90°. They are much intersected by quartz veins crossing the strike from N.E. to S.W. They also contain numerous intercalated beds or stratiform masses of red felspar, some of which pass into a regular granite by acquiring quartz and mica from the adjoining schists, and all of them show more or less a tendency to become granitic. In some places the felspar is pure, in others associated with quartz alone, and again, in other places, with mica to the exclusion of quartz. The schists are metamorphosed from a finely laminated magnesian clay-slate to talc and mica slates, which again become *gneiss* in the vicinity of the granite, by the interlamination of felspar. Where the felspathic mass is considerable, a regular granite is formed by a mixture of the felspar with the quartz and mica of the schists. At the junction the granite is generally very large-grained. From this mass the veins and apparent beds exposed in the sea-cliff proceed. One of the veins is five or six feet thick at the bottom, thinning to about two or three at the top of the cliff. It is generally a medium-grained granite, but in many places almost wholly flesh-coloured felspar. A thin seam of large-grained granite (three-fourths of an inch thick, and almost entirely felspar and mica) occurs at the junction with the schist. Fragments of the latter are also enclosed in the granite in many places. The schists appear to have been simply argillo-arenaceous strata, metamorphosed first into a sort of *clay slate,* then into *mica slate,* with the characteristic quartz layers; next, by a higher

degree of metamorphism and the absorption of felspar, when in a soft state through heat, into *gneiss;* and, finally, by absolute fusion with the felspar, into granite. All these gradations are seen here in the most instructive manner, and in every variety.

The Peterhead granites are chiefly composed of red felspar and quartz, the mica being very subordinate. They are occasionally fine-grained and light grey, like the Aberdeen granite, and enclose numerous fragments of schists. At one place, upon the shore, near Peterhead, a dyke of very beautiful flesh-coloured felspar, about twenty-four yards wide, runs E. by S. to W. by N. This is occasionally *granitoidal.* Near this is a large mass of felspar or felspar porphyry, containing veins and nests of quartz. Along this part of the shore the felspar rock is more abundant than the granite. It is also met with in the Stirlinghill quarries. The Aberdeenshire granites appear to be simply the result of the invasion, upon a large scale, of the primary schists and quartz rock, by this *standard igneous rock.* The nature of the resulting granite depends wholly upon that of the associated schists.

To the foregoing examples many others might be added, but those given have been selected on account of the clear and instructive character of the junctions, and their comparatively ready accessibility. Fassney Water and Glen Tilt, both classic in geology, might have been added; but as this paper has already exceeded the limits intended, it would be improper at present to enter at greater length upon the subject, although it is one admittedly of very high interest. The writer trusts that his labours in this field may induce other and more competent observers to examine and thoroughly test the correctness of his investigations, by a direct appeal to the rocks themselves. He would particularly impress upon observers the importance of taking notes of the positions of the divisional planes of the granites and porphyries, and comparing them with the directions of the planes of stratification of the nearest rocks of aqueous origin.

II. *On the Water which permeates through Strata, considered as a Dynamic Power.* By Andrew Taylor, Esq.

The writer is unaware that physical geologists have rightly appreciated the fact that vast bodies of water are held in great masses of the strata of various formations, under conditions admitting of the operation of two well-known hydraulic laws. It is proposed merely to call attention to this power in geological dynamics without entering into any detailed consideration of its extent and limits.

The first of the hydraulic laws referred to is thus expressed by Dr Arnott in the new edition of his "Elements of Physics:"—"In a quantity of fluid submitted to compression the whole mass is equally affected, and similarly in all directions. A given pressure, therefore, made upon an inch of the surface of a fluid confined in a vessel as by a plug forced inwards, is suddenly borne by every inch of the internal surface of the vessel, however large, and by every inch of the surface of any body immersed in the fluid." This law is well known from the numerous popular illustrations of which it is capable, such as the Bramah Press and the bursting of a water barrel from the pressure of water admitted into it by a long tube of very small bore. It is the most advantageous way known of employing a small force to counteract a very great one. Thus, "through the medium of a confined fluid, a force of one pound, acting upon an inch square of the fluid surface in a vessel, may become a bursting force of ten, or a hundred, or a thousand pounds, according to the size of the vessel, or may be used as a mechanical power to overcome a force much more intense than itself." Taking this law in conjunction with another about to be mentioned, Sir William Armstrong has given the world that powerful mechanical invention the "Accumulator," by which the heaviest loads, such as draw-bridges with heavy railway trains, may be lifted with the most perfect ease. This second law is thus expressed by Dr Arnott: —"In any fluid, the particles that are below bear the weight of those that are above, and there is therefore a pressure among them, increasing in exact proportion to the perpen-

dicular depth, and not influenced by the size, or shape, or position of the containing vessel." These two laws are practically exhibited in the Accumulator in the following fashion:—A reservoir of water is placed at a convenient height from the power on which it is proposed to operate. A heavy weight is made to press upon the reservoir, and a communication is made with the engine which is to apply the power gained, by means of a tube of very small diameter. It is found that the power thus practically gained is equal not to that represented by the pressure of the weight upon the reservoir, but to that pressure *plus* the pressure of an imaginary reservoir equal in depth to that of the connecting tube from the reservoir to the engine.

If, then, natural reservoirs of water in the rocks have a mass of superincumbent strata pressing on them, and a communication be opened downwards by a narrow outlet, the pressure at the spot where the outlet terminates must be governed by the same laws. That such forces actually exist is undoubted. And they may be a possible cause of such natural phenomena as the reappearance of rivers which have flowed for some time in a subterranean channel, the outburst of fresh-water springs in the sea, or in places where no declivity is known sufficient to account for their outburst on a plain.

When, however, we estimate the water which is absorbed by porous strata as existing in a natural reservoir, and pressed down by impervious strata above, this hydraulic problem will have a much wider geological application. It will likewise require nice discrimination to determine how much the faults and fissures of the strata are due to this cause, and in what degree to other physical forces.

The amount of rain-fall is quite sufficient to afford the means of such a power in almost any situation. It has been calculated that every inch in the depth of rain falling upon a single acre is equal to one hundred tons, so that there falls 3000 tons-weight of rain annually upon every acre, or, daily, $\frac{880}{365}$ tons. The rain-fall varies at certain seasons of the year. Mr Bailey Denton states that, at Hinxworth, the discharge from the open lands amounted, in January and

February, to about 1000 gallons per acre per diem. Again, on the clay lands, the fall from October till 12th December 1856 was about 160 gallons per diem per acre; while on the 9th January 1857, the outlets ran 125 gallons per diem; but on the 10th the discharge was increased from 125 to 5150 gallons per diem per acre. Such sudden accessions of water upon places of the rocks already subjected to pressure, but not at other times sufficient to effect a dislocation, may be the immediate cause of many a landslip, or of such a threatened calamity as was lately impending on Greenside from the Calton Hill.

In such a rock as the Calton Hill, the surface rain-water from the crown of the hill will penetrate down to a certain limit, which, adopting the phraseology used in describing sections of chalk hills, we shall call the water-line. This line will be situated at no great depth from the surface of the hill, probably not much below the stone steps which aid the traveller to enter its precincts. In estimating the pressure of the rain-fall contained in the sectional area above the water-line, the undulating contour of the hill must be considered. We shall thus obtain a section, the height of which indeed is limited, but the horizontal area of which is considerable, and, as we have already seen, the pressure on a spot of the section immediately abutting on the water-line will be equal in depth to an imaginary section represented by a straight line drawn from the highest point, where the water is absorbed, to a perpendicular drawn from the point of pressure.

The line of saturation in chalk districts has been ascertained to be generally about 1 in 400, or 13 feet per mile; while in other parts of the chalk districts the inclination of this line is probably not less than 40 feet a mile. No such observations have been made on this line in trap rocks; but their absorptive power is well known. And especially through rocks containing so many ash-beds as the Calton Hill much water must permeate.

The author next proceeded to show that hydraulic pressure, such as had been attempted to be shown existed in the rocks, would be best developed in the basins of the

mesozoic and tertiary series of strata, where pervious strata, capped by those which were impervious, have an area of many miles in extent. The lower greensand, for instance, which surrounds the London basin, is capable of absorbing daily the enormous quantity of 146,000,000 gallons of water, and this bed alone has a subterranean area estimated at 4600 square miles. Mr Prestwick assumes the thickness of this bed to be 200 feet, so that the whole capacity of the subterranean water-bearing mass will be equal to 920,000 square miles, one foot thick. The hydraulic forces resulting from the pressure of the overcapping strata on this bed, which is virtually a water reservoir, will act in two directions, and the pressure will be equal. A force will unitedly press from either side of the basin; and the most powerful strain of both will be on the centre of the basin. It is certainly, then, somewhat curious that a fault generally should be found in the centre of these jurassic and tertiary basins; and that the course of a river should generally be in the line of this fault. Add to this the fact, that borings for artesian wells are generally successful only within twenty metres of the river, and there appear to be sufficient data to excite the inquiry whether such hydraulic pressure, as no doubt actually exists in the strata, may not have been the proximate cause of these faults.

III. *Ornithological Notes.* (*With exhibition of Specimens.*) 1. *Anthropoides virgo* (Numidian Crane); 2. *Syrrhaptes paradoxus* (Pallas' Sand-Grouse); 3. *Falco subbuteo* (Hobby); 4. *Pernis apivorus* (Honey Buzzard); 5. *Bombycilla garrula* (Bohemian Waxwing); 6. *Botaurus stellaris* (Common Bittern); 7. *Botaurus lentiginosus* (American Bittern); 8. *Mergulus melanoleucos* (Rotche or Little Auk); 9. *Circus cyaneus* (Hen Harrier); 10. *Parus cristatus* (Crested Titmouse); 11. *Loxia curvirostra* (Common Crossbill); 12. *Alauda arvensis* (Sky-Lark—a black variety); 13. *Phalaropus lobatus* (Grey Phalarope). By JOHN ALEX. SMITH, M.D.

Since the close of last session some of our rarer birds have been captured in different parts of the country. I shall refer to several which have come under my own immediate notice, taking them principally in the order of their occurrence:—

1. *Anthropoides virgo.*—"A fine male bird, in beautiful plumage, of the Demoiselle or Numidian Crane (*Anthropoides virgo*), was shot on Thursday last, 14th May 1863, at Deerness, east mainland, Orkney, and has since been preserved for Mr Reid, bookseller, Kirkwall.

"Two of the birds were seen at Deerness for some days, and were pursued and shot at several times. When the one was killed the other flew over to the neighbouring island of Copinshay, and was not afterwards seen by the Deerness folks, who describe the flight and walking of this remarkable bird as something very graceful, and such as they had never witnessed before.

"Although these birds (which are natives of Africa) feed on aquatic animals, small fish, frogs, &c., in their native haunts, nothing was found in the stomach of this one but oats, several grains of which were also found adherent to its tongue. It was not starved like—weighing about five pounds, being considerably heavier than our herons.

"The gulls and lapwings continually attacked the two strangers, whenever they walked or winged their way over the grass and oat fields, and they were heard frequently to utter a hoarse scream when thus persecuted by their tormentors.

"The Demoiselle is quite new to Orkney, and is a valuable addition to our large list of birds. As far as I can find in any work on British birds, it is new to Britain in a wild state. It has been imported, however, and may be seen in a domestic state in the garden of the Zoological Society.

"Since the above was written we learn that a day or two after the first had been shot, the other Demoiselle returned to Deerness from Copinshay, and was again seen in the fields, most probably in search of its mate. Several parties endeavoured to stalk it, but without success. It is described by some of the country folk who have watched it as a very large bird, 'looking nearly as big as a sheep,' which of course must be taken with a considerable limitation, as the birds are both most likely about the same size. We believe the extreme height of the specimen in Mr Reid's possession is about three feet, and the spread of the

wings about five feet, but the exact measurement has not been given."—*John o'Groat Journal.*

This specimen is in the possession of Mr Reid, bookseller, Kirkwall, and I am indebted to Mr H. Osborne, Wick, for the account of its capture. I have also been favoured with a letter from Mr R. I. Shearer, Ulbster, about this capture of the crane. He considers they were not birds escaped from confinement, the possibility of which I had suggested to him; as they were very wild and shy of approach, and as the pair were seen together at the first, he therefore believes it is an addition to our British birds, being the first time it has been noticed in our Island.

2. *Syrrhaptes paradoxus*—the Sand-Grouse or Pallas' Sand-Grouse. In June last several flocks of these very rare birds were observed in different parts, especially of the east of Scotland.

I have had an opportunity of examining several specimens, both of males and females.

A male bird was shot near Montrose, where a small flock was observed, and several specimens, I believe, were captured.

A flock was also noticed near Berwick, and two males and two females were shot on the 12th of June 1863. These birds were in fine plumage, and by the kindness of Mr Sanderson, George Street, were carefully examined by me. The black bands of the male are represented by a rich brown in the female, and the central projecting tail feathers were much longer in the males, which were not smaller than the females. Their stomachs contained white turnip seed.

In the neighbourhood of Seacliff, East Lothian, a male bird was shot on the 17th of June; and a male bird was also killed at Leithhead, near Kirknewton, on the same day; its stomach contained seeds of the brown bent grass. A young bird was taken alive on Paisley Moss in July 1863. It was the only one observed there, and allowed itself to be captured by the hand. The bird was in the possession of Mr Small, bird-stuffer, George Street here, and I saw it run nimbly about the cage in which it was confined.

The following is a detailed description of the two most perfect specimens which I examined. They were shot near Berwick :—

Male.—Measures 15⅛ inches long from bill to point of the two elongated feathers of tail, which are 3½ inches longer than the other tail feathers. Length of wing from flexure to point of elongated first primary, 10½ inches; first primary elongated point 1½ inches longer than second, which is also, like the others, pointed. Bill small, dark blue, tipped with black. Top of head light buff or fawn colour, with lighter yellowish line over eye, behind the ear becoming of a chestnut colour. The back and upper parts fawn-coloured, feathers broadly edged with black, and some tipped with white—upper tail coverts similar. Chin and throat covered by a rounded patch of chestnut, with defined line of black below it. Neck and breast fawn colour. Feathers at lower part of breast lighter in colour, and edged with narrow black lines, forming a narrow band across breast; below this band the abdomen is fawn-coloured, and behind this again, a band of very dark brown, or rather black, crosses the abdomen in front of legs. The under tail coverts are dirty white, the base of the feathers being darker. Wing, pointed; smaller coverts are fawn-coloured, showing only one or two small round spots of black. Secondaries, reddish brown, forming a bar across the wing when closed. The quills have the central ribs black, like tail, and are of a bluish grey colour on their outer webs. First primary longest, its outer edge black, produced to a setaceous point; others regularly diminishing in length—axillaries white. The tail is fawn-coloured, outer webs dashed with bluish grey, and inner barred with dark brown or black; the two middle feathers are produced to fine black points or filaments. Legs and feet closely covered all round with short fawn-coloured feathers. Toes rather broad, and conjoined or concrete; no hallux; below bare, and skin reticulated.

Female.—13 inches in length. Middle tail feather 1⅞ beyond others. Wing to point of primaries, 8½; first primary ½ inch longer than others. Bill dark blue, tipped with

black ; nostrils, like male, covered with feathers. Yellowish line of lighter colour over eyes and passing to behind ears. Throat yellowish, with defined line of black below it. Top of head and upper parts of body fawn-coloured, and feathers more or less edged or barred with black, changing into small round spots on sides of neck. Below, fawn-coloured, no narrow bar of black across breast as in the male. Across abdomen, in front of legs, a broad band of chestnut brown. Wing—smaller coverts fawn, with round spots of black. Secondaries, under edge of small coverts, reddish brown, forming a bar across wing. Bastard wing, with black edges, same as male. Quills—first primary longest, point slightly produced, second very slightly produced, only pointed like others, which gradually diminish in length. Outer web of first primary, black; others bluish grey, and white at edge, the inner webs being dusky. Greater coverts fawn, outer webs black, edged with light fawn in male, in female almost white; inner webs fawn colour—axillaries white. Tail fawn, barred with brown. Under tail coverts dirty white. Legs feathered like male. Nails broad and dark brown.

Sir William Jardine, in a note to the "Edinburgh Philosophical Journal" for July 1863, quotes a letter in the "Times" noticing a specimen in the Derby Museum, Liverpool, which had been sent from Perth, and gives a letter from Professor Dickie of Aberdeen, stating that two birds had been shot in the beginning of June out of a flock of about fifteen, near Munchals, seven miles south of Aberdeen. Their stomachs contained turnip and grass seeds.

Mr H. Osborne sent me the following notice of one shot from a small flock near Wick on the 8th of June:—

"A fine specimen of this interesting and very rare bird was shot in a field on the farm of Westerseat, n[illegible] Wick, on Monday last, the 8th inst. A small flock, nu[illegible]bering from ten to twelve individuals, had been observed [illegible] the same locality a day or two before feeding among th[illegible] young braird. The birds were by no means shy when pur[illegible]sued. The specimen referred to, which was t[illegible] only one that fell to the shot, was presented to Dr Si[illegible]

be preserved and added to the valuable collection of Caithness birds possessed by that gentleman. It is very remarkable that this bird, hitherto so rare in Britain, has, within the past few weeks, appeared suddenly in small parties in various and widely-separated districts of England, a circumstance first observed by Dr Sclater, who communicated the information in a letter to the *Times*. . . . . The first British specimen was procured in Norfolk in 1859. A second specimen, obtained about the same time, was placed in the well-known Derby Museum at Liverpool. Till then it was considered doubtful whether the bird could be included even in the European list. The Prince of Canino gave it a place, but it was omitted by Gould, Temminck, &c. The entire length of this curious bird is about fourteen inches. The female is rather larger than the male, and weighs about eleven ounces. . . . . The Sand-Grouse will form a very interesting addition to the already extensive list of Caithness birds."

Mr R. I. Shearer informs me that a Sand Grouse, one of a pair, was also shot at Ulbster, Caithness, by Mr Bently-Innes, in 1863.

These birds are natives of the steppes of Tartary and China, and before this strange irruption of them into Britain, they were considered very rare indeed.

At the British Association meeting at Newcastle in August 1863, Mr A. Newton, F.L.S., read a communication "On the recent irruption of Pallas' Sand-Grouse," stating that to his knowledge 109 of these rare birds had been killed in the British Isles, of which 63 were shot in Norfolk and Suffolk.*

3. *Falco subbuteo*—the Hobby. In the month of July last a small hawk was shot near Portobello, and from the statement of the bird-stuffer who examined it, describing it as a miniature Peregrine Falcon, with a similar black cheek and moustache, there seems little reason to doubt it must have been a specimen of the rare Hobby. A few instances only of its occurrence as a summer visitor in England have

* See short note of the paper in the British Association Report for 1863, p. 105.

been recorded, and M'Gillivray states that the northern limits of its range in Britain appear to be the counties of Durham and Cumberland. It is generally distributed over the Continent. Unfortunately this specimen was too long of being brought to the bird-stuffer, and could not be preserved.

4. *Pernis apivorus*—the Honey Buzzard, one of our rarer summer visitors, was killed by a gamekeeper at Biel, East Lothian, in the month of July, as I am informed by Mr John Dickson, gunmaker, Princes Street, who preserved the bird. Its stomach was crammed full with wasps and their larvæ, some of which I examined; more than could be held in the hand being removed. The bird had been shot very soon after a hearty meal.

5. *Bombycilla garrula*—the Bohemian Waxwing. This beautiful bird is an occasional winter visitor. Two specimens, a male and a female, were shot at Sunlaws, near Kelso, about the 13th of November last.

6. *Botaurus stellaris*—the Common Bittern, now one of our rare birds. The specimen, exhibited by the kindness of Mr James H. Sanderson, was shot near Mousewald, Dumfriesshire, in the beginning of the month of January.

7. *Botaurus lentiginosus*—the American Bittern. Mr R. I. Shearer, Ulbster House, informs me that a specimen of this very rare bird was shot at Latheronwheel, Caithness, by F. S. Bently-Innes of Thrumster, Esq., in the autumn of 1862. It is easily distinguished from the Common Bittern by its more freckled appearance; indeed it has been named by Montagu the Freckled Bittern, the black dash or stripe on the neck is larger and more distinct than in the Common Bittern, and begins a little farther back from the angle of the mouth. The bird is also less in size than the Common Bittern, which, it may be remarked, seems never to have been observed in the county of Caithness. The American Bittern is only a rare straggler to Britain. Several instances have been recorded of its appearance in England. The only other instance known to me of its occurrence in Scotland, was one killed at Jardine Hall, Dumfriesshire, in October 1844, and described by Sir William Jardine.

Mr Shearer also informs me he saw in the neighbourhood of Ulbster a beautiful mature specimen of the *Strix nyctea* (Snowy Owl), on the 3d of June last, but was unable to capture it.

8. *Mergulus melanoleucos*—the Rotche or Little Auk, an occasional winter visitor. One was shot near Kinghorn, Fife, in the beginning of February.

9. *Circus cyaneus*—the Hen Harrier. A beautiful adult male of this species, now unfortunately become rather rare here, like many of its allied species, from the wholesale destruction of all the interesting birds of this Class by our excessive game preservers. It was shot at Thrumster, Caithness, in the month of March, and is still common, I believe, in the north of Scotland.

10. *Parus cristatus*—the Crested Titmouse. No less than nine specimens of these rare birds are now exhibited. Twelve of these birds, males and females, were shot in the beginning of March at Ballindalloch, the property of Sir C. Macpherson Grant, Bart. It seems to be local in its distribution, and from its small size, is perhaps not easily seen in our great pine forests of the north of Scotland. These rare birds appear to be more abundant, or at least have been more frequently observed, in the great forests of Speyside than in any other part of Scotland.* In 1859 I exhibited

* In the recently published and interesting volume on "Natural History and Sport in Moray," collected from the Journals and Letters of the late Mr Charles St John (Edin. 1863), the following details are given of the history of this rare and little known bird:—"I know no bird so confined to particular spots as the Crested Titmouse. Their only regular place of abode, as far as has been ascertained, is the large forest near Grantown on the Spey; there they build tolerably abundantly in the decayed clefts and holes of the old fir trees, making a smaller nest than most other birds of the same genus. They lay about six eggs, white, with dark-red spots. Their habits are like those of other titmice, searching the trees for small insects, and flying from branch to branch, uttering a loud shrill cry. . . . . This is the dullest coloured of all the titmice, but easily distinguished by its remarkable crest, which it erects with great facility. It is little known as a British bird. My attention to it as such was first called by Mr Dunbar (formerly of Inverness, now of Brawl); since then, I had frequent opportunities of obtaining both the bird and the nest from the forest of Glenmore, near Grantown, and I have every reason to believe that it frequents some of the upper woods of the Findhorn, near Dulsie, though not so commonly as the first-named forest."—P. 20.

to the Society one in my possession, taken near Dumbarton. (Proc. vol. i. p. 242.)

The next birds exhibited were also from the same locality.

11. *Loxia curvirostra*—the Common Crossbill. Two young birds or females, also shot at Ballindalloch in the beginning of March. These birds visit Britain in flocks at uncertain intervals, and occasionally breed in this country.

In conclusion, I exhibit an example of one of those strange changes in the colour of the plumage which occur in birds: in this instance, in the

12. *Alauda arvensis*—the Sky-Lark, *a black variety.* It was caught near Granton, about two years ago, in company with a number of other larks, and its plumage at the time was noticed to be rather darker than the others. The birds were all kept together in a large cage and supplied with the same food, canary seed and pease-meal,—no hemp seed, which has been supposed to favour this change of plumage, having been given to them; this specimen alone gradually became at its moulting quite black in its plumage, in the course of about twelve months.

Some *white* varieties of this bird have also been noticed; one is now exhibited from the University Museum, to which it was presented by Dr Sidey, who has also kindly sent this black one for exhibition. The black variety is considered to be the result of disease, perhaps also of diet, and has apparently occurred principally in birds kept confined in cages, and not in their wild state.

I am indebted to Mr Sanderson and to Mr Small, bird-stuffers, George Street, for many of the other birds exhibited.

13. *Phalaropus lobatus* (Grey Phalarope). Two specimens of this bird were shot in Caithness-shire in October 1863, one having been killed in Wick Bay on the 7th, and the other near the South Head, by Mr W. Peach, on the 19th. This is the first time this bird has been observed in the county of Caithness.

Mr Henry Osborne, Wick, has since informed me of the appearance in Caithness-shire of the *Bombycilla garrula*, the Bohemian Waxwing, at Rosebank House, near Wick,

on the 12th of November 1863; it fed on the berries of the mountain ash.

A number of these birds appear to have been observed about the same time in different parts of Britain, an instance of which indeed has just before been recorded.

Thanks were then voted to the Chairman and office-bearers; and the Society adjourned to the commencement of next winter Session.

PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

NINETY-FOURTH SESSION, 1864–65.

Wednesday, November 23, 1864.—DAVID PAGE, Esq., President, in the Chair.

The Rev. John Duns, D.D., F.R.S.E., Professor of Natural Science, New College, Edinburgh, was balloted for, and elected a Member of the Society.

The New Part of the Proceedings was laid on the table.

The following Donations to the Library were laid on the table, and thanks were voted to the Donors:—

1. Proceedings of the Royal Society, London. Vol. xiii., Nos. 62, 63, 64, 65, 66, 67. 1864—From the Royal Society. 2 Journal of the Proceedings of the Linnean Society, London. Vol. vii., No. 28, April 1864. Vol. viii., Botany, No. 29, June 1864. Vol. viii., Zoology, No. 29; Botany, No. 30, September 1864—From the Linnean Society. 3. Canadian Journal of Industry, Science, and Art. New Series. Nos. l., March; li., lii., liii., September 1864—From the Canadian Institute, Toronto. 4. Amtlicher Bericht über die acht und dreissigste Versammlung Deutcher Naturforscher und Aertze in Stettin im Sepr. 1863. Herausgegeben von den Geschaftsführern Derselben. Dr C. A. Dohrn und Dr Behm. Stettin, 1864—From Dr C. A. DOHRN, Stettin.

The President, Mr DAVID PAGE, delivered the Opening Address:—

ON THE PRESENT ASPECTS OF GEOLOGICAL INQUIRY.

GENTLEMEN,—In resigning this chair, which long indisposition has compelled me to fill with less efficiency than I could have wished, allow me to congratulate you on the continued prosperity of our Society, and then to pass on to a brief review of the present position and future prospects of geological inquiry.

That the Society might do more work, and that its meet-

ings might be more numerously attended, is sufficiently obvious to all of us; but considering the number of similar institutions—each having for its object some special branch of research which necessarily comes within the scope of the Royal Physical—the wonder is, not that we should have occasionally to complain of a thinly-attended meeting, but that every meeting should have its quota of new observation and discovery. That we are indebted for this result to a few of our number, more zealous and active than the rest, must be readily admitted; and while we tender to them our warmest gratitude, we may be allowed at the same time to express the hope that their example may in the future have its due influence on others, and especially on the junior fellows. He must be a dull student of nature who does not occasionally observe a new fact, and he must be an indifferent or self-sufficient one who does not consider that observation worthy of communication to others, or regards his own explanation of it as beyond revision or correction. The prime object of our Society is to record observation, and in that record to seek to discover the nature and order of the producing causes, and thence, if possible, to arrive at the law or laws by which these causes are related to the entire system of nature. Beyond this there is no higher attainment in physical science, and as humble but earnest students we seek by our fellowship in the Royal Physical Society to encourage and facilitate each other's efforts towards this attainment. Should we fail to determine laws, we may at least endeavour to discover producing causes; and even should we fail there, we may at all events continue to observe and place our observations on record for the benefit of others. This much, surely, lies within the reach of every member of our brotherhood; and as the field of nature is vast, and its objects innumerable, the least and most restricted of us might continue to contribute his mite to the furtherance of our common object.

Geology, as one of the main departments of natural science, and one to which most of the others are more or less related, claims necessarily a large share of our attention; and thus, on the opening of a new session, a brief review of

its present position and future prospects may not be without some advantage. And here, at the outset, it may be remarked that the study of geology was never in a more equable and well-balanced condition. No one branch seems to be in the ascendant, or cultivated exclusively to the detriment of others. Mineralogy and the discrimination of rock-species are not now regarded as constituting the science of geology; nor is it the fashion to allow palæontology to absorb the whole of our interest and attention. Mineralogy and chemical geology, palæontology and physical geology, have each their students and cultivators; and though occasionally some novelty like the "Origin of species" or the "Antiquity of man" may temporarily arrest the attention, yet on the whole the students of our many-sided science seem convinced that its general progress can be best promoted by every one labouring in that department to which he has been led by his natural predilections, and for the cultivation of which he has the greatest facilities. It is thus that the chemistry of our science is promoted by such researches as those of Bischoff, Delesse, Hunt, and Haughton; its physics by those of De Beaumont, Hopkins, Thomson, Mallet, and Sorby; its palæontology by Agassiz, Owen, Hall, Huxley, Pictet, De Köninck, Milne Edwards, Pander, Davidson, and others too numerous for detail; its stratigraphical successions by Murchison, Logan, Ramsay, Jukes, Rogers, Barrande, Hochstetter, Oldham, Hector, Selwyn, and others entrusted with Government and colonial surveys; its systemal connections and higher generalisations advanced by such writings as those of Lyell, Phillips, Darwin, Dana, and Sedgwick; while in every county and provincial district a host of local observers are each contributing his mite of observation and discovery to the general fund of geological progress. No other branch of natural science, indeed, has of recent years made such rapid and substantial progress as geology; and though many problems yet remain to be solved and old errors to be exploded, still, on the whole, we may well congratulate ourselves on the nearer and hopeful attainment of something like an intelligible world-history. The increase of local observers, the augmented facilities for

travel, the institution of Government surveys by the different nations of Europe, the States of America, and our wide colonial possessions, are every year adding immensely to our geological stores; while every new addition enables us to arrive at sounder conclusions than could be derived from the limited data supplied by our own little islands. But while all this is satisfactory for the present, and encouraging for the future, there are still many points requiring immediate and careful consideration, and to some of these I would now direct the attention of our Society.

Fundamental Strata.—Premising that all demonstrable geology commences with the oldest stratified rocks, the question naturally occurs, Where and what are these oldest strata? We have traced life down to the Cambrian grits and slates, but beyond these lie the more crystallised gneiss, quartz rocks, and granitoid schists of the Northern Hebrides. Shall we, with Sir Roderick Murchison, designate these the "fundamental gneiss," and seeking their equivalent in the Laurentian schists of Sir William Logan, regard them as the earliest and oldest of our stratified system? Even in these Laurentian strata, metamorphosed and crystalline as they are, Sir William Logan and his assistants, and more recently Principal Dawson, have detected traces of lowly organisation,* and in some portions more metamorphosed than others, more traces may yet be discovered. Time was, and that within the memory of most of us, when the lower Cambrians were considered as *azoic*; but now that life has been carried downward into an older and deeper system, true philosophy requires that we discard in the meantime all ideas of "fundamental rocks" and "primordial zones," and leave the beginning of our stratified systems, like the origin of life, an undetermined, though not a hopelessly determinable problem. We may admit into our tabulations the Cambrian and Laurentian as well-defined and fossiliferous systems; but dealing with rocks so metamorphosed and

* A foraminiferal organism, *Eozoön Canadense*, occurring among the serpentinous limestones in large sessile patches, after the manner of *Carpenteria* and *Polytrema*. The same organism has been more recently detected in the Connemara marbles of Ireland.

obscure in their stratification, we must not regard them as the oldest or deepest, but merely the oldest and deepest with which we are at the present time acquainted. Finding that the traces of life are year after year carried deeper and deeper in the stratified rocks, and that in the older Silurians and upper Cambrians (the Lingula flags) the number of discovered organisms are also greatly augmented,* we are clearly not in a position to dogmatise on fundamental strata or primordial zones, and far less to regard any series of strata, however altered and crystalline, as *azoic* and *hypozoic*. Even where traces of life may be too obscure for the eye and microscope of the palæontologist, the tests of the chemist may detect the presence of organic matter, *or mineral products that could only result from the presence of organic matter;* and thus we are clearly debarred from doing more than merely placing *provisionally* the Cambrian and the Laurentian strata as our oldest stratified and fossiliferous systems. I say *stratified* and *fossiliferous*, for my own belief is that life was coeval with the first-formed sediments; and that the meteoric and aqueous conditions that promoted the formation of sediments were such as would permit, at the same time, the development of vegetable and animal existences. Let us then accept provisionally the "Cambrian" of Professor Sedgwick and the "Laurentian" of Sir William Logan as separate and fossiliferous systems; but let us discard all ideas of "fundamental strata" and "primordial zones," and at the same time let us abandon such terms as *azoic* and *hypozoic* which are founded alone on the uncertain and unsatisfactory basis of negative and uncertain evidence.

Metamorphism.—The consideration of these older sediments brings us necessarily in contact with the subject of *metamorphism*, and on this point it seems to me that modern geology, under the sanction of high authority, is insensibly drifting into error. And, in the *first* place, it may be observed, that where any series of metamorphic strata have a clearly defined position, that is, are sequentially connected

* See the discoveries of Mr Hicks, in the so-called "primordial zone" or Lingula flags, as noticed in the *Journal of the London Geological Society* for August 1864.

with other fossiliferous strata, or contain, in some of their less metamorphosed beds, remains whose age can be determined, there can be no error and much advantage in calling them by the name of the system to which they belong, and discarding the term metamorphic. But where all sequential connection is lost, or at all events obscure and uncertain, and where not a trace of organism has been detected, as in the schists of our Scottish Highlands, it seems to be safer and more philosophical to regard them as simply "metamorphic," rather than designate them by the name of any system—Silurian or Cambrian—to either of which, to both of which, or to none of which they may yet be discovered to belong. The geological map of Europe is made more intelligible by marking the metamorphic strata of the Alps (for example) by the colour of the system to which they belong, but it is more than questionable how far the geology of Scotland is explicated, or the science itself promoted, by delineating, as has been recently attempted, the crystalline schists and quartzites of the Highlands as lower Silurian. As a fact, the term *metamorphic* conveyed no error; as a hypothesis the designation *Silurian*, in absence of all fossil evidence, imparts no new knowledge, and tends to retard investigation. In the *second* place, some geologists are evidently carrying the idea of metamorphism beyond its legitimate limits, and would ascribe to its intenser manifestations the production of the granites and granitic compounds. Now, no one who has studied the porphyritic gneisses of our own Highlands will deny that some granites may be the result of intense metamorphism; but to assume that all granites have had this origin, and that none of them are truly eruptive rocks, is, in my opinion, an obvious error. Carry, if you will, with Sir William Logan, metamorphic action to such intensity as to render the masses plastic or semifluid, and what then? Simply this, that you have a highly heated or vulcanic product capable of being forced into rents and fissures, and to all intents *intrusive.* But does it never occur to those who would deny the eruptive character of some granites, that these granites, like the schists with which they are associated, have undergone a

metamorphism of their own, and that they were originally truly igneous like the basalts and greenstones. Place, for example, the carboniferous and old red strata of Edinburgh, with their associated porphyries, basalts, and greenstones, at great depths in the crust, and subject them to metamorphic action, and what would be the likely result? Evidently, that while the sandstones and shales and limestones and ironstones were being converted into crystalline schists and marbles and hæmatites, the porphyries and greenstones would also undergo metamorphism, and be changed into granites and syenites. So in all probability it has been with the old crystalline schists and their associated granites—both have undergone a metamorphism, but the former is not less sedimentary, nor the latter less eruptive or igneous, because of this internal mineral re-arrangement. Let us then clearly understand what we mean by the term *metamorphic*, and take care how it is applied. It is a convenient term for altered strata whose age we cannot determine by the aid of fossil organisms. It is a sound designation when applied to altered rocks, whether sedimentary or igneous; but its action, however intense, does not affect the fact that such rocks were primarily of aqueous and igneous origin. Some granitic masses may be merely highly metamorphosed schists, but that does not affect the circumstance that others are truly igneous, though altered in their mineral texture by a similar metamorphism. The truth is, every substance in the earth's crust is continuously and incessantly undergoing metamorphism—the latest eruption of lava, as well as the latest deposition of sea-silt, or the vegetable layer which last summer's growth contributed to the gradually increasing peat-bog. Heat by contact, heat by transmission, conduction, or absorption, heat by permeation of hot water, electric and magnetic currents, chemical action and reaction, molecular re-arrangement under pressure, and the like, are all conducing to this mineral change; but though we fail to detect in every instance the producing causes, we need not on that account, and for the sake of some cherished hypothesis, confound the obvious results.

Passage Beds.—Another point of our science which re-

quires careful and cautious consideration is the systematic disposal of what have been termed "passage-beds," or strata that lie between and partake of the characters of two contiguous systems. There are, for instance, passage-beds between the Silurian and the Old Red, between the Old Red and the Carboniferous, between the Trias and Lias, and in all likelihood between most of the other great stratified systems. The final disposal of such strata involves the question, What constitutes a system? Shall we regard a system as a great series of strata characterised by the same facies of organic remains? or shall we consider a system as bounded on both sides by great physical breaks or unconformities in stratification? If we adopt the former view, the line between systems must often be vague and uncertain; and if we adhere to the latter, we find that physical breaks are not always followed by an immediate and total change, either in the flora or fauna. The truth is, that in this, as in other geological questions, we must adopt a somewhat provisional course, avoiding sharp lines of demarcation, and using the term "passage-beds" where neither mineral nor fossil characters are decided enough to lead us to a conclusion. Were we to adopt the views of some, the lowermost Old Red flagstones of Scotland would rank as uppermost Silurian; while the uppermost yellow beds would go to form the base of the Carboniferous formation. In this way the Old Red Sandstone of Scotland would be reduced to mere subordinate formation, and this without rendering more intelligible the boundary between Murchison's Siluria and Devonia on the one hand, or giving to the officers of the Irish Geological Survey a surer basis for their Carboniferous system on the other. In the same way with the Rhaetic and Penarth beds that lie between the Trias and Lias. In some districts the fossil assemblage seems to point to the Lias, and in others to the Trias, and where there is no physical break it matters little to which system we assign them. But where a physical break or unconformability occurs, that break should be held as the boundary between the Triassic and Jurassic systems. And, more than this, where such questions cannot be solved by the examination of British strata, we should appeal to the

wider field of foreign geology; ever remembering that what is limited and irregular in one district may be continuous and regular in another, and that we are bound always to take the fullest development we can discover as the typical standard of our groups and systems. Let us then abide by this idea of *passage beds* as a provisional convenience, avoiding all sharp demarcations between contiguous systems, believing that nature's operations are incessant and continuous, and that all breaks, whether physical or vital, are at the most but local and limited phenomena.

Systemal Arrangements.—A fourth point to which we would direct attention is the discovery of numerous secondary coal-fields, and the effects of such discoveries, *first*, on many cherished theories respecting the conditions of the Carboniferous era; and, *second*, on the chronological arrangement of our secondary formation. The fact that we have important coal-fields of triassic, oolitic, and cretaceous life, like those of Virginia, Brazil, Vancouver's Island, Austria, India, the Indian Archipelago, and Australia, must for ever set aside as untenable all hypotheses of abnormal climates, carbonic acid atmospheres, and universal conditions for the carboniferous epoch. The fact is, that coal is a product of every age, and that the coal-forming conditions, like other conditions, will vary in intensity according to the geographical arrangement of sea and land, and the consequent climatic influences which such arrangements may induce. Besides, we are far from having proved the strict contemporaneity of the so-called Palæozoic coal-fields; on the contrary, every new foreign survey raises the gravest doubts on this point, and leads to the belief that these old coal-deposits range throughout the whole cycle embraced by the Devonian, the Carboniferous, and Permian systems of the British Islands. Again, the difficulty which foreign surveyors find in co-ordinating their discoveries with our trias, lias, oolite, and chalk, suggests the idea that the time is not far distant when we must modify the range and nomenclature of these arrangements. Be it from America, India, Australia, or New Zealand, complaints are continually reaching us of the difficulty, or even impossibility, of co-ordinating their strata with those

of the British systems. To abide by these systems were to set up our petty archipelago as the type of the wider world, and to retard the progress of geology; and we may rely on it that the time is fast drawing near when we must both modify and intercalate—modify what we now consider systems, and intercalate others to which there is no equivalent in these islands. It is true that, under the present "systemal arrangements," geology has made most excellent progress, and these on that account should not be lightly abandoned; but to be ever forcing unnatural co-ordinations is obstructive alike to truth and the labours of the distant observer. As the old arrangements of Lehman and Werner gave way to the wider knowledge of the present day, so we may naturally expect the arrangements of the present to be superseded by the more exact information of future observers.

Contemporaneity.—And this difficulty of co-ordination brings us, in the fifth place, to remark on the very difficult but most important question of *contemporaneity*, or contemporaneous formations. Hitherto the general idea has been that identity of genera and species in any set of strata, however widely separated, was proof of contemporaneity of deposit. Founding on this notion, a thousand facts in geology became inexplicable; but believing that species and genera in time past had their centres and areas of distribution just as they have at the present day, and that under the oscillations of sea and land they may have taken ages to travel from one hemisphere to another, the difficulties vanish, and we require to call in no abnormal conditions of universal sameness of life, sameness of climate, changes in the earth's axis of rotation, or such like causes, at total variance with all that we know of the present ordainings of the universe. Identity of species, therefore, unless in limited areas, instead of proving contemporaneity of deposit, would go to prove the reverse, and would merely show that the areas in which they are now found fossil had at one time or other the means of transference placed between them. From this view, then, it by no means follows that the palæozoic coal-fields of America were contem-

poraneous in formation with those of Europe, or that those either of Europe or America were synchronous with those of Australia. On the contrary, thousands of ages may have intervened between their depositions; and all that we can attempt, or philosophically are permitted to attempt, is co-ordination in fossil forms and similarity of conditions, but not co-ordination in time or synchrony of formation. Take, for illustration, the post-glacial beds of the Clyde, that contain certain species of shells now extinct in the latitudes of Britain, but which still flourish in the seas of Greenland. The post-glacial era is separated from the present by an immense lapse of time; and yet, were the muds of the Greenland seas and the clays of the Clyde presented to future palæontologists, they might, according to the practice of co-ordinating by species, be regarded as contemporaneous. Nothing, however, could be further from the truth; and so nothing is more likely to be erroneous than many of the contemporaneities that have been attempted by geologists. In the very nature of things, few species can have a world-wide distribution; the spread of plants and animals from their specific centres is slow and gradual; and the oscillations of sea and land that produce these external conditions, favourable or unfavourable to the geographical transference of life, are also extremely gradual. As in dealing with the problems of physical geology we reason from the present to the past, so in dealing with organic questions we must reason, in like manner, from the existing to the extinct. At present, no two regions present the same specific facies, and we are not to presume that any other order prevailed in bygone ages. If we argue for uniformity in the *forces* of nature, we can scarcely refuse to admit a similar uniformity in her *methods*. According to this doctrine, each area in time must have been peopled by its own specific forms; and, as at the present day, different species may be entombed in widely-separated deposits, which are strictly synchronous, so in former epochs, as has been well remarked by Professor Huxley, "absolute diversity of species is no proof of difference of date, just as absolute identity can be no evidence of contemporaneous

deposition." We may, and must as far as we can, establish a similarity of order—*homotaxis,* as it has been termed—between the strata of different regions, but similarity of order is not to be confounded with synchrony of deposit; and we must, therefore, if we would place the solutions of our science on a philosophical basis, abandon, as all sound geologists are rapidly abandoning, the idea that specific identity of fossil forms is proof of stratigraphical contemporaneity.

Quaternary accumulations.—Another point materially affecting the present position of our science, and one of the last to which our time will permit me to refer, is the very unsatisfactory arrangement of the post-tertiary, quaternary, or superficial accumulations. It is true we may generally classify them according to the agents by which they have been formed, or, in other words, according to their composition and the causes by which they have been produced. In this way we have fluviatile, lacustrine, marine, chemical, organic, and igneous accumulations, but this conveys no idea of succession or history in time. What our science requires is, that we endeavour to arrange them in chronological order, as we have done with the earlier systems. The arrangement proposed by the late Dr Fleming into taragmite, akumite, and phanerite is so purely hypothetical, and so obviously at variance with observed facts, that it has not been, and cannot indeed be accepted. The broader arrangement into *pre-human* and *human* periods is obviously too general to be of much advantage to working geologists, at the same time that it can give us no clue to determine when the pre-human ends and the human begins. Again, such terms as the "Leda clay" of the St Lawrence and the "Saxicava sand" of Montreal, though good and distinctive enough for local purposes, are inappropriate for other regions; and others, as "Pampean formation," "Erie clay," and the like, merely announce a geographical fact, without conveying any idea either of fossil remains or chronological sequence. Had the post-tertiaries, like most of the tertiaries, been strictly sedimentary, some percentage system of fossil forms like that by which Sir Charles Lyell

threw so much light and order over the latter might have been adopted. But these post-tertiaries being here terrestrial and there lacustrine, here fluviatile and there turbary, here marine and there fresh water, prevent any such arrangement, and we must seek some other method more general and provisional. Perhaps the oldest of our post-tertiary deposits are those raised beaches and marine silts that immediately followed the glacial epoch, and in which the remains of seals, whales, and boreal shells are most abundant; next in order are the lacustrine, fluviatile, and estuarine silts and drifts, marked by the remains of mammoth and other elephantine forms; then follow the lake and bog silts and peat-mosses, containing bones of deer and oxen; and lastly, we approach accumulations containing works of human art and civilisation, and this brings us to the dawn of history. In this way we arrive at a *cetacean*, an *elephantine*, a *bovine*, and a *historical* period; and this, so far as Europe is concerned, might be adopted provisionally and without involving much error. But when we seek to apply it to South America, to Australia, or to any other distant region, it fails as a distinctive arrangement, and we are driven to seek some other that is strictly local, and which can only be coordinated in a general way with our European accumulations. Altogether the arrangement, or rather non-arrangement, of our quaternary accumulations is a reproach to our science, and no finer field presents itself to the young geologist who would benefit his study or advance his own reputation. Sequential arrangements we must have, and whether these be founded on lithological or on fossil evidence, he will be no mean benefactor to his science who first indicates the way to a solution of the difficulty.

Antiquity of Man.—And here it may be remarked, that it is this want of sequential arrangements among quaternary deposits that has surrounded the question of the antiquity of man with so much doubt and difficulty. We are every day hearing of the discovery of bones and flint implements in "the drift." But what drift? Is it the glacial drift, or later river drift? Is it drift formed in times immediately post-glacial, or in ages immediately pre-Celtic? At the

present moment there is the widest and vaguest notions as to the relative ages of these implement-yielding deposits, and until more light shall have been thrown on the age and sequence of all post-tertiary accumulations, the antiquity of man must continue to remain an unsettled and perplexing problem. Indeed the problem is at the present moment in a more unsettled state than it was eighteen months ago; and all that has been really gained by the discussion is, that it has been made an open question—a subject which any geologist may discuss from a purely natural history point of view, without having his motives suspected or his orthodoxy called in question. I say "natural history point of view," for there is no reason why he may not discuss the antiquity of man with as much freedom and philosophy as we discuss the antiquity of the mammoth or mastodon. It is true, and it is much to be regretted, that some inquirers have unguardedly mingled up the question of man's origin with that of his antiquity. The two questions, however, stand on widely different platforms. The one involves considerations purely stratigraphical; the other considerations at once physiological and geological—involves, in fact, the whole theory of life and life-development. Let us not, then, be led away from a problem that is hopefully soluble into one which, if not beyond our solution, is placed at all events so much beyond our present reach that generations may pass away before we arrive even at the methods by which the solution is to be attained. Adhering to the whole question of the antiquity of man, whose own remains and the remains of his rude implements have been found along with those of the mammoth and tichorine rhinoceros in the quaternary deposits of Europe, let us first determine the chronological sequence of these deposits; and then, before giving expression to our beliefs in years and centuries, let us carry our researches into Asia and Africa, where there is every reason to believe that mankind existed for ages before his ruder offshoots found their way to the shores of Western Europe. My own opinion is, that this question of man's antiquity has also suffered by the injudicious haste of some observers to give numerical expression to their beliefs. That

mankind existed for ages beyond the commonly-received chronology, few geologists who have studied the question can for a moment have any doubt. But whether this were sixteen thousand or sixty thousand years, we have no means of determining, and all numerical expressions merely excite the hostility of the prejudiced, and provoke unnecessary and retarding discussion.

Life—Progressive Development.—Lastly, this question of man's antiquity naturally suggests the comportment of geology towards the whole subject of *vital development* as deducible from the facts of palæontology. Admitting the order of ascent from lower to higher forms (and numerous as the missing links may be, no one has yet denied this order of ascent on the great scale), the question still remains to be solved—and geology, as the originator and establisher of the doctrine of vital progression, is bound to consider it—How, and by what means has this progress from lower to higher forms been effected? There are two methods, as we have elsewhere observed,* by which the problem seems capable of solution, though both require much more minute and extensive observation than science has yet at her command: *first*, the changes in the organisms themselves may be such as to indicate the manner in which they have been affected, and, by inference, the causes that produced them; and, *second*, if there is a law of perpetual progression, it must be still operative on living plants and animals, and we might arrive at its nature by a careful study of the variations which existing species undergo, and the proximate causes on which these variations depend. Than these, scientifically speaking, there is no other way of approaching the question. To appeal to the doctrine of creative acts and the will of the Creator, is to put the question beyond the limits of science—to treat it as a matter of faith, and not as a subject of logical investigation. As geologists, it is evident we must deal with the problem as one of natural history—reasoning from result to cause, and from the order of causation to the higher bearings of a general and enduring law. There need be no uneasy tenderness in dealing with

* Philosophy of Geology: Blackwood & Sons, 1863.

the question of Life, any more than in dealing with the questions of metamorphism and crystallisation. In all its phases and surroundings—in its growth, reproduction, and decay—it is under the immediate operation of physical laws. A little more heat or a little more cold, an excess of drought or an excess of moisture, the exclusion of the air or the withdrawal of the sun, are sufficient to influence, or even to destroy, its existence ; and though we may never be able to comprehend the origin of life, we clearly perceive that all its subsequent manifestations are closely bound up in definite order with the operating forces of the universe. As such, the question of vital development becomes, philosophically, not only a fitting subject for our research, but one whose every bearing is hopefully within our determination. Impossible or not, the loftier we direct our aims, the higher at all events will be our scientific efforts to attain them ; and to shirk the question through fear of arousing unworthy prejudices would be to belie at once our position as students of nature, and subordinate that spirit of inquiry with which God has endowed us to seek to comprehend His workings in the wonderful world that surrounds us.

Such, gentlemen, are some of the points in geological inquiry that appear to me to be worthy of your attention. Had the time permitted, we might have adverted to the opposing theories of *upheaval* or *accumulation* in volcanic action as an important element in geological chronology; to the present unsatisfactory state of *palæontology* as regards nomenclature, unnecessary multiplication of species, and in particular as regards the neglect of fossil botany; to the doctrine of *uniformity* in natural law as sufficient to account for the phenomena of the past; to the question of surface-configuration as arising from *meteoric* and *aqueous* operations, or from *glacial* action ; the law which seems to regulate the recurrence of *colder* and *warmer climates* over the same latitudes, and to several other questions that still continue as moot points among geologists ;—but enough, I presume, has been said to show that our science, notwithstanding all its progress, has yet many problems to solve and difficulties to remove. That many of these difficulties will speedily be

removed, the progress of geology during the last quarter-century gives us every reason to be hopeful. The number of observers has increased immensely, and is yearly on the increase. Geology is now taught in our schools as a branch of elementary education. An acquaintance with its leading doctrines is required in most of our professional examinations, and it ranks as an item in all the competitive trials for civil and military service. The surveys instituted by the different governments of Europe and the States of America, along with those more recently set on foot in our colonial possessions, must also add amazingly to our stock of sound and accurate knowledge, and thus it is the future progress of geology is rendered so hopeful and encouraging. It may never be the lot of our race to attain to a perfect history of our planet—the records of past life being so fragmentary, the various formations being so denuded, disturbed, and altered, and so great a portion of the earth's crust being permanently hid from investigation by the waters of the ocean—but enough, we presume, remains to enable us to trace the great outline of such a history; and such institutions as the Royal Physical Society best fulfil their functions when their members labour diligently within their own districts to observe and record—each well-established fact becoming a permanent addition to the chapters of this marvellous history. There are few districts possessing so much geological interest as Edinburgh and the adjacent counties—few where the physical phenomena are so varied, or where the producing causes and modes of operation are so apparent. There is none of us so restricted in this range that he may not contribute his mite of observation, and even should he fail in this, he can give at all events the hand of fellowship and encouragement to others. And after all, when the substantial rewards of science are so few, it is this encouragement, this pleasurable fellowship that forms half the recompense, and he who bestows it cordially and with no niggard hand, is fairly entitled to take rank with the worker, and share in the honours of his discoveries. In this spirit then, let us continue to contribute to the progress of geology—working in the field where we can, and where we cannot,

encouraging those who do, by those graceful acts of fellowship which so well become the members of a Society devoted as ours is to the study of God's works in the beautiful and orderly world that surrounds us.

A vote of thanks, moved by Mr Alexander Bryson, and seconded by Dr James MacBain, was unanimously given to Mr Page for his valuable and instructive Address, and for his services as President of the Society.

The following Communications were read:—

I. *Ornithological Notes.* (*With Exhibition of Specimens.*) 1. *Falco gyrfalco* (The Jerfalcon); 2. *Pernis apivorus* (The Honey Buzzard); 3. *Tetrao hybridus* (Hybrid between Capercailzie and Blackcock); 4. *Syrrhaptes Pallasii* (Pallas' Sand-Grouse); 5. *Parus cœruleus* (Blue Titmouse, yellow variety); 6. *Thalassidroma pelagica* (The Storm Petrel). By JOHN ALEX. SMITH, M.D.

1. *Falco gyrfalco* (Yar.); the Jerfalcon.

This fine specimen of this rare bird, the largest and finest of the falcons, was shot by Robert Ainslie, Esq., of Elvingston, at Muirton, near Beauly, Inverness-shire, about the 24th of September last.

The bird is a female, and measures 27 inches in length from beak to point of tail. The wing, from flexure to point of primaries, 16 inches. The second primary is the longest, and the first shorter than the third.

I shall give a short description of the plumage of the bird, for comparison with other specimens, as there are still difficulties about the distinctions of males, females, and young.

Bill pale blue, tipped with black; tooth sharp, and festoon distinct. *Legs and feet* pale blue, and claws black. *Head* dusky brown, with slight white markings on the top, which become larger on the sides of the neck behind. *Upper parts* of body dusky greyish-brown; feathers with dark central line, and edged with narrow borders of buff. *Tail* slightly rounded, of twelve feathers, the two middle ones dark brown, faintly barred with lighter brown at the upper or basal part; the lateral tail feathers with transverse

continuous bars of lighter brown or buff colour. *Under parts* dark brown, each feather showing a large, elongated, longitudinal blotch or spot of brown, and edged with light brown. These spots commence under the chin and on the neck as narrow longitudinal lines, and gradually expand into large dark blotches over the under parts of the body.

Young females appear to be generally dark in their plumage; and it is believed by some naturalists that the young males are generally of a lighter style of colour; this may, however, still want confirmation. I am indebted to Mr Sanderson, bird-stuffer, for exhibiting the bird.

It occurs apparently only as a rare occasional visitor in this country, where it has not been known to breed, according to most naturalists. Mr Macgillivray, however, in his "British Birds," adds a note, on the authority of a correspondent, that it breeds on St Kilda. The Arctic regions are its true home; and it is only occasionally seen in Britain, generally in the winter months.

In November 1860 I exhibited a young male, which had been shot in North Uist, in the month of October previous. (See Proc., vol. ii. p. 226.)

2. *Pernis apivorus* (Flem.), the Honey Buzzard.

The bird exhibited is a young male. It was shot about the 21st of September, at Wellwood, near Muirkirk, Ayrshire, by William Grass, gamekeeper to James Hunter, Esq., of Auldhouseburn. It had been observed in the neighbourhood some little time before, and was killed while perching on an old tree.

The keeper states that he trapped a bird of the same species in the September of 1863, but it broke away on his going up to the trap, leaving part of a leg behind, which he still has in his possession. I never hear of these horrid traps, without being sorry for the wholesale destruction of harmless, inoffensive, and beautiful birds, as in this instance, which they are sure to occasion; all true naturalists must mourn over the destruction of any of our fine eagles and hawks, for the paltry gratification of the possession of a few more heads of game.

The length of the bird was 24 inches. The *upper parts* are of a rich dark brown; the small scale-like feathers in front of eye being of a greyish brown; the secondaries are edged with light brown, almost white; feathers of neck with a dark line down the centre of each, which gradually spreads into large spots or blotches over the lower parts of the body. *Tail* of twelve feathers, brown, crossed by numerous irregular bars of a lighter colour, and tipped with buff.

Under parts, brown; feathers edged with light brown. *Bill* black, with cere yellow. *Legs and feet* yellow, and claws black.

The *stomach* contained a hairy mass, apparently the remains of caterpillars and insects.

Two specimens of this bird were previously exhibited by me to the Society, which were shot in the month of June.

The bird is generally considered as one of our rare occasional summer visitors.

3. *Tetrao hybridus* or *Tetrao medius*, Hybrid Grouse.

This bird, a hybrid between the *Tetrao urogallus* the capercailzie, and the *Tetrao tetrix* or blackcock, is a male, which sex is described as occurring more frequently than the female. It was shot in the beginning of October at Tulliallan, the seat of Count Flahault, near Kincardine, on the Forth. It is nearly intermediate in size, and also in colour, between the capercailzie and the blackcock, measuring 26 inches in length, and weighed 5½ lbs. It is probably the progeny of a male blackcock and a strayed capercailzie hen. Its general colour is darker than the capercailzie, its bill black, and its breast shows a brilliant band of reddish purple, violet, or Orleans plum-coloured reflections, a combination I suppose, of the steel-blue of the blackcock and the green of the capercailzie. The tail has the three outside feathers prolonged on each side, gradually increasing in length to the outer, which is the longest, exactly the reverse of the tail of the capercailzie, and resembling in this respect the blackcock.

In December 1858, I had the pleasure of exhibiting to the Society the first of these hybrids which I had seen in Scotland. (Proc., vol. ii. p. 44.) It was shot in Perthshire.

Mr Yarrell mentions their well-known occurrence in Norway and Sweden, and states, "there was every reason to believe they had formerly occurred in Scotland." I am not aware of any other recent notice of these hybrids having been previously observed in this country.

4. *Syrrhaptes Pallasii*, Pallas' Sand-Grouse.*

The specimen exhibited was taken alive in Paisley Moss in July 1863, and was referred to in my Notes on Birds, read to the Society last Session. Since that time it has been carefully kept in confinement, having been purchased by Lord Binning, it was, however, at last unfortunately killed by an accident about the middle of October. The bird is probably a young male. It wants the prolonged primaries of the adult, but has the pointed extremity of its central tail feathers, which project about 2 inches beyond the rest of the tail. Upper parts of head and back pale reddish brown, with numerous transverse markings of dark brown or black. The chin and throat are fawn-coloured, and it has the narrow dark-brown line dividing the neck from the upper part of the breast. The breast and front of the neck are pale greyish brown, and the sides of neck yellowish brown or buff, marked over with round spots of dark brown or black; but no defined line of dark brown yet separates the breast from the abdomen as in the adult male. The abdomen is of a dirty buff, the back part being crossed by a broad band of dark brown, almost black; behind, and under tail coverts, greyish white.

5. *Parus cæruleus*, the Blue Titmouse, yellow variety.

The specimen exhibited shows a curious variety in the

* In a note since received from Mr R. I. Shearer, he informs me that the sand-grouse which was shot near Wick, as noticed in my Notes of last session, had been feeding at the time on a particular kind of grass, of which he sent specimens, its crop being quite filled with it. Mr Shearer found "on examining the ground that this grass only grew in certain circumscribed localities, and in every place where the sand-grouse had been seen for about a week previously to the time that one of them was shot, this grass was found more or less abundantly; it grows there in certain barren spots about the sides of the hill tracts or horse roads." The grass sent by Mr Shearer, Professor Balfour kindly informs me, is the common *Poa annua*.

plumage of this common bird, which was killed in Inverness-shire on the 20th of July. At first sight it might almost be mistaken for a canary, as it is entirely of a uniform yellow colour, with the exception only of the secondaries of the left wing and the two middle tail feathers, which retain somewhat of their original bluish colour. There is also a faint belt of dusky at the back of the head. The bill, legs, and claws are nearly white; most of the secondaries and tail feathers are yellowish white; the whole of the rest of the plumage being of a pale yellow colour. The eyes were stated to have been of a dark or black colour.

The yellow tint, I may remark, prevails as an original colour of the bird, which is, however, developed into rich green and blue in the perfect bird. Macgillivray, in his "British Birds," states, that although the tints of the plumage of this bird vary much in depth and purity, he has not met with any accidental changes of colour.

6. *Thalassidroma pelagica* (Selby), the Storm Petrel.

These birds are occasionally driven inland by the storms of our early winter months; and, during the severe gales of last month, small flocks were observed, and birds caught at various places, as at Ormiston, Seacliff, North Berwick, Portobello, Granton, and at Cramond Island, and also near Motherwell, Renfrewshire. The specimen exhibited was picked up in an exhausted state, at 10 P.M. on the night of the 24th October in the Cowgate here, and died before morning. Its capture has already been chronicled in the newspapers by our assistant Secretary, Mr J. B. Davies.

I am indebted to Mr Sanderson and Mr Small for sending various specimens of the birds for exhibition to the Society.

II. *Exhibition of Heads of the* Cervus elaphus, *Red Deer, showing curious varieties in their Antlers; uith Remarks.* By JOHN ALEX. SMITH, M.D.

The heads of deer exhibited, for which I am indebted to Captain W. P. Orde, younger of Kilmory, were shot in his

forest of North Uist, in the month of September last. The horns are well marked and characteristic, though of rather a small size, as is to be expected in the island deer. One of them is a royal stag of twelve, and another of eleven points.

The two heads, however, of special interest, are those strangely formed and distorted ones, of which *one head* has the right horn bent backwards, and measures 7½ inches in length, a short brow antler, 4 inches long, rises upwards from it in front, the second or bezantler is 5½ inches in length, but points backwards; and behind this, or rather immediately at the back of this, is the end of the beam, projecting as a mere point. The horn of the left side of the head has a longer, slightly bent and tapering beam, which measures 17 inches in length; with two short points, the brow antler about 1¼, and the bezantler 2½ inches in length. *Another head* has the beam of the right horn thrown completely backwards, and 9 inches in length, ending in a short and rough hook-like extremity, and the brow antler (the only one present) projects forwards, and is 10 inches long. The left horn has the beam also bent back, short, and broad, and 8 inches in length; the brow antler turned backwards, and 7 inches long, the second or bezantler also bent backwards, and 3½ inches long, with merely a small, short point projecting above it; beyond which the beam bends backwards, and terminates in a rough hook-like extremity. The teeth are perfect in both skulls, eight incisors and six molars in each jaw, and two tusks in the upper jaw of each.

Captain Orde states that these deer were both in good condition, and he considers the peculiarly formed horns to be those of very old deer; that after they have attained to old age, the horns become smaller, and also generally irregular in character, as these are. He mentions that for the last twelve years very few deer have been killed in the forest of North Uist, and that several other deer, showing similar peculiarities, have been also noticed in the forest. The peculiarly formed ones he is inclined to consider may be also due, to a certain extent, to deterioration from the comparatively small number of the deer, breeding in and

in ; cut off, as they in a great measure are, by their insular position, and thus prevented from mixing with the deer over a more extended range of country.

There appears to be no doubt that with great age the horns of the stag do lose their size, and return at last, it is said, to the simple spire or beam with the brow antler alone, and it has been believed that some of these horns showing irregularities of form may be due to great age. It is not improbable also that some deteriorating effect may be caused from the breeding in and in of a small flock of deer, though we know that the strongest deer are the fathers of the herd. It has also been supposed that these varieties in form might be the result of injuries received by the horn itself in the earlier stages of its growth ; the most probable cause, however, may be considered to be any injury of an exhaustive nature received by the stag either in the previous autumn or spring ; and the effect of castration in stopping or altogether preventing the growth of the horns is well known. In a work entitled " Notes on the Chase of the Wild Red Deer in Devon and Somerset," by Charles Palk Collyns, surgeon, published in London in 1862, this subject is pretty fully discussed. Mr Collyns states, that " from frequent investigations and dissections, I have come to the conclusion that the appearances (of short and distorted horns) have been generally due to shot or slug injuring the deer in his testicles before his horns are shed, or during the growth of the new horn," or " to accident or over-exertion during the season preceding the shedding of the horns." He has also observed " the testes to have been injured on the same side where the defective horn appeared."

It would therefore be an interesting addition to our knowledge of this curious subject, if Captain Orde would cause any of the deer showing these irregularities in the size or shape of the horns, to be carefully examined for the traces of previous injuries of any kind sustained by them, in the region of the testes especially, or in any other part of the animal.

In November 1856, I exhibited a curious analogous variety in the horns of a red deer, in which the first or brow antler

came from the back part of the distorted beam, and passed backwards over the head (See *Proc.* vol. i. p. 222); this stag was believed to have been of great age.

I have in my possession the head of a full-grown and mature fallow deer, *Cervus dama,* also showing a considerable variation from the ordinary arrangement and shape of the horns. They measure each about 13 inches in length; the right horn has a small brow antler 1½ inches long, a longer bezantler of 5 inches, and the beam, which is only very slightly expanded, is much narrower than usual, and has two projecting points at its upper part; while the left horn has the brow antler represented by a small knob or point projecting from the surface of the horn, another point higher up may represent the second antler; while the beam is hardly expanded at all, showing merely a small point on the back, and terminates above in a single point.

In November 1857, Mr Andrew Murray exhibited a curiously contorted variety of the horns of the Reindeer (*Proc.* vol. i. p. 363, with figure), the distortion being rather curiously very much alike on each of the horns.

These varieties in the character of the horns of various deer may suggest a little caution in our description of species, as, had we found any such strangely branched horns in our gravels, marl-beds, or peat-bogs, we might have been tempted at least to think about the possibilities of additional species of some of these genera.

In conclusion, I may mention, that the largest head of horns of any recent Scottish stag of which I have notes, was a park-fed deer, the property of the late Duke of Athole, which was killed by another stag about fourteen years ago. It displayed no fewer than 18 points on its horns: and the cast horns of the previous year were 18 lbs. avoir. in weight.

Wednesday, December 28, 1864.—WILLIAM TURNER, M.B., President, in the Chair.

The following Gentlemen were elected Office-bearers for the Session:

Presidents. — David Page, Esq.; William Turner, M.B.; Thomas Strethill Wright, M.D.

Council.— A. M'Kenzie Edwards, Esq.; Alexander Bryson, Esq.; William S. Young. Esq.; James M'Bain, M.D.; Ramsay H. Traquair, M.D.; Stevenson Macadam, Ph.D.

Secretary.—John Alexander Smith, M.D.

Treasurer.— George Logan, Esq., W.S.

Assistant-Secretary.—James Boyd Davies, Esq.

Honorary Librarian.—Robert F. Logan, Esq.

Library Committee.—Thomas Robertson, Esq.; Andrew Taylor, Esq.; W. Rhind, Esq

The following Donations to the Library were laid on the table, and thanks voted to the Donors:—

1. Proceedings of the Royal Society, London. Vol. XIII., No. 68, 1864.—From the Royal Society. 2. Notes of a Trip to Iceland in 1862. By Alexander Bryson, F.R.S.E., F.G.S.—From the Author. 3. Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt, 1863. Band XIII., Nro. 4. Oct., Nov., Dec.—From the I. R. Geological Society of Austria. 4. (1.) Transactions of the Royal Irish Academy, Vol. XXIV. Polite Literature, Part 1, 1864. Science, Part 3, 1864. (2.) Proceedings of the Royal Irish Academy, Parts 1-6, Vol. V., 1863-64.—From the Academy. 5. Report read by the Astronomer-Royal for Scotland to the Special Meeting of Her Majesty's Government Board of Visitors of the Royal Observatory, Edinburgh, Nov. 1864.—From Professor C. Piazzi Smyth. 6. Notes and Queries upon Geological Matters, No. 1 (several copies).—By G. E. Roberts, Esq., F.G.S., &c.—From the Geologists' Association, London.

A large and very fine adult specimen of the African mandrill baboon, the largest of the dog-faced quadrumana, was sent for exhibition to the Society. It had been purchased, and was preserved by Mr Small, George Street, for an interesting local collection—the Macfarlane Museum, Bridge of Allan.

The following communications were read:—

I. *On the Restoration of Bone.* By A. M'KENZIE EDWARDS, Esq., F.R.C.S.E.

II. (1.) *Note of a Specimen of the* Rhombus hirtus (Yar); *Muller's Top-Knot, recently taken in the Firth of Forth.* By John Alex. Smith, M.D. (The Fish was exhibited.)

This fish was taken in a crab-pot, off Newhaven, on the 30th June 1864.

It is short, oval, or rounded in shape. The specimen measures 8 inches in length. The head to angle of operculum $2\frac{3}{8}$ inches, length of body $4\frac{5}{8}$ from angle of operculum to base of caudal rays; caudal rays 1 inch in length in middle of tail. Greatest breadth of body about middle, $3\frac{3}{4}$ inches, not including fins; across fins also, behind large central black spot, nearly 5 inches.

The upper and left side of the body is of a brown or wet sand-like colour, spotted all over with darker brown, principally at the outer margins; there is one large and very distinct dark spot a little behind and above the pectoral fin.

This surface of the body is rough, felt especially by the finger when drawn from the tail towards the head.

The lateral line curves upwards at its commencement, and passing through the black spot runs straight towards the middle of the base of the tail.

The whole of the under or right side of the body is white and smooth.

The upper eye extends about half the breadth of the orbit behind the lower. Teeth thickly set in both jaws.

The fins round the margin of body of fish are of a reddish brown colour. The ventral and anal fins are united; the dorsal and ventral become membranous at their extremities, and pass below the root of the tail towards the mesian line of the under side, and are separated from each other by a space about a quarter of an inch in length. The first ray of the dorsal fin is not longer than the others, and the dorsal, as well as the anal fins, gradually increase in length until within an inch of the base of the tail; from this point they rapidly shorten to the membranous portion of the fin.

Of the pectoral fins, the left or upper fin is larger, and longer than the right or lower pectoral fin—*left or upper* fin

is 1 inch long, and has ten fin rays; the *right or under* fin about ¾ of an inch long, with eight fin rays.

Dorsal fin,	. .	90 fin rays
Ventral,	. .	6 ,,
Anal,	. . .	70 ,,
Caudal,	. .	14 ,,

I have been thus particular in details, as there appear still to be doubts about the distinction of the species of this genus. (See *Proc.*, Vol. II., p. 139 and note, and p. 258.)

(2.) *Note of the* Atelecyclus heterodon (Leach), *the Circular Crab, from the Firth of Forth.* By John Alex. Smith, M.D.

The fine specimen now exhibited was sent to me as a rarity by Mr Charles Muirhead, Queen Street. It was taken on the 14th of July from the stomach of a codfish caught off the Berwickshire coast, near the mouth of the Firth of Forth.

The crab is a full-grown female. It measures 1½ inch in length by 1½ in width. The abdomen consists of seven joints or segments, and is slender in shape, being three times as long as broad.

Mr Bell, in his "British Stalk-Eyed Crustacea" states that the male is much more abundant than the female. He gives the size of the male as 1¼ inch, and says the female is much smaller. The female specimen exhibited measures, however, fully 1½ inch in length.

The carapace is granular and rough; the lateral margins have nine teeth, alternately large and small. It is fringed with hair; thorax smooth below, the legs all fringed with long hair.

Only one or two instances of its occurrence in the Firth of Forth have been recorded. It is therefore considered rare, and an inhabitant of deep water, which is borne out by its being found in the stomach of the cod taken in deep water.

I have much pleasure in presenting the specimens of the *Rhombus hirtus* just described, and this Circular Crab, to the Natural History Museum of the University, through our Assistant-Secretary, Mr J. B. Davies.

Wednesday, January 25, 1865.—T. Strethill Wright, M.D., President, in the Chair.

Rev. James Brodie, Monimail, Fife, was elected a non-resident member of the Society.

The following Donations to the Library were laid on the table, and thanks were voted to the Donors :—

1. (1.) Transactions of the Zoological Society of London. Vol. IV., Part 7, Section II., 1862 ; also Vol. V., Part 3, 1864. (2.) Proceedings of the Zoological Society of London, 1861. Part 3, June-December ; also Parts 1, 2, and 3, January-December 1863.—From the Society. 2. (1.) Transactions of the Royal Society of Edinburgh. Vol. XXIII., Part 2, Session 1862-63. (2.) Proceedings of the Royal Society of Edinburgh, Session 1862-63.—From the Society.

The following Communications were read :—

I. *Observations on the Development of the Pleuronectidæ.* By Ramsay H. Traquair, M.D.

That both eyes of a turbot, or of any of its congeners (*Pleuronectidæ*), are situated on one side of its head, is a fact long interesting to naturalists, in connection with the peculiar habits of those animals. It also affords an interesting field for the anatomist and embryologist, to ascertain what relation this asymmetry bears to the morphological plan of the fish-head in general. And, indeed, if we merely look at the exterior of such a fish as the turbot, the manner in which the transposition of the eyes has been effected is not very apparent. It is true, it is easy to imagine that the mesial line of the top of the head has been simply twisted to one side, carrying with it the eye of the opposite. But the dorsal fin, which stretches all along the back in what is assuredly the mesial line of the fish, extends also uninterruptedly in the same straight line on to the head, beyond the eyes, and between the nostrils, to nearly the end of the snout. If the middle line of head has been twisted, why has such a distinctly median structure as the dorsal fin not undergone the same process at its cephalic extremity?

Or we may imagine that in early development one of the

eyes has passed bodily through the head, beneath the dorsal fin, till it has reached that side where both are now found, and where it has formed for itself a new and anomalous orbit; a view which, it must be confessed, grates a little against most of our preconceived morphological ideas.

But from what we see on the outside of the fish, we can only rashly speculate. It is only by anatomical and embryological research that we can gain an insight into the true state of the case.

As I am looking forwards at no distant date, to the publication, elsewhere,* of a detailed account of the osteology of the flat-fish head, considered in relation to the asymmetry of these fishes, I will, in this communication, content myself with a brief review of the theories which have occurred to various writers on this subject. And especially I shall inquire as to what light embryology, including the examination of monstrosities, has as yet afforded us.

Autenrieth is the oldest writer I have found to allude to the subject anatomically, in a paper on the anatomy of the Plaice (*Platessa vulgaris*), published in the year 1800.† His remarks on the osteology of the Plaice are however meagre, and his theoretical conclusions will seem to us now-a-days absurd; for he accounts in the following manner for the position of both eyes on the right side of the head. He says, "The examination of the skeleton shows us that the entire left side of the fore part of the cranium is in reality wanting, and that nature, in order not to lose an eye, was necessitated to put it into the hollow of the right cheek, under the alone remaining right orbit."

Rosenthal (Ichthyotomische Tafeln, Berlin, 1812–22), a little more rational in his ideas than Autenreith, held the upper eye of the flounder to be that of the left, or now eyeless side, but accounted for its getting to the right side by its being thrust through the head and getting placed be-

* Transactions of Linnean Society for 1865.

† Wiedemann's Archiv für Zoologie und Zootomie. Thl. i. 1800, s. 47, *et seq.* "Bemerkungen über den Bau der Scholle (*Pleuronectes platessa*) insbesonders und den Bau der Fische hauptsächlich ihres Skelets im Algemeinen," Von Dr T. H. F. Autenrieth, Prof. der Anatomie in Tübingen.

tween the long processes of the frontal bones, after the manner of cyclopean malformations. The view which occurred to him is then in accordance with the second theory suggested in the beginning of this paper, but which a careful examination of the osteology of a series of different species of flat-fish will easily show to be untenable.

It is, however, to Meckel* that we owe almost all our previous knowledge of the subject, as far as the structure of the adult Pleuronect is concerned. He recognised correctly the homologies of the various cranial bones, with those of the symmetrical fish, and was undoubtedly the first who saw clearly that, according to the first theory already suggested, the two eyes of the flat-fish are brought round to one side, by the turning or twisting round of the middle line of the head; but his notions as to the prolongation of the dorsal fin along the head, and its strange position as regards the eyes, are unsatisfactory, as we shall see afterwards.†

Van Beneden,‡ in 1853, published a paper, the first in which notice has been taken of the development of the Pleuronectidæ. In this paper, he has described a young turbot, taken probably soon after its extrusion from the egg, and in which that stage of development does not seem yet to have been reached, when the eyes become both placed on one side. " In this young fish the mouth is perfectly symmetrical, the eyes are still on the two sides of the head, but the left is about to pass over to the right side,—the nostrils are still symmetrical. The rays of the dorsal fin only yet descend to the middle of the cranium, afterwards they stretch on in front of the eyes, but it is necessary first, that the twisting of the head should have taken place in the vertebral column."

To these observations, he adds the result of some made " on a turbot of nearly adult size, in which the process of torsion is arrested when the eye has arrived at the middle line. The rays of the dorsal fin have not yet descended

* System der Vergl. Anatomie. Thl. ii. Halle, 1824.

† See the author's forthcoming paper " On the Asymmetry of the Pleuronectidæ" in the Transactions of the Linnean Society, 1865.

‡ System der Vergl. Anatomie. Thl. ii. Halle, 1824.

to more than in the embryo described, the two sides are equally closed."*

In remarking upon this paper, I may commence by saying, that here, for the first time, do we find distinctly announced the fact and doctrine, that the dorsal fin is not primarily advanced so far forwards in the head as we find it in the fully developed flat-fish, but that it advances after the eyes have turned round, and that it then advances straight forwards, regardless of the deviation of the original middle line of the head. Thus we are afforded a ready and rational explanation of the difficulty which met us at first, namely, as to how, if the middle line of the top of the head has been twisted to one side, the dorsal fin, a mesial structure, has not followed that twisting. Van Beneden, however, is not the first to notice an occasional condition of the adult flat-fish, similar to that which he has described in his embryo, but it seems to me to be the first to appreciate properly the morphological value of such phenomena.

Schleep, in "Oken's Isis," for 1829. p. 1049, has described and figured an adult turbot, similar to the one referred to by Van Beneden, and to which he has given the name of *Pleuronectes maximus duplex.* The two eyes are still on each side of the head, the upper is just about to make the turn, and the anterior part of the dorsal fin has not yet advanced beyond the eyes, but projects over them in a free pointed process. Schleep seemed to have some little doubt as to whether he should consider this specimen as belonging to a distinct species, or as merely a variety or monstrosity, but is more inclined to believe in the latter solution of the question. He merely describes the outside of the animal, and makes no remarks on the morphological significance of its conformation.

Yarrell, in the second volume of his "British Fishes," has figured the head of a Brill (*Rhombus vulgaris*), with a similar condition of the fore-end of the dorsal fin. The upper eye seems to be set nearly on the top of the head. He also mentions having seen similar specimens of the turbot.

* Note sur la Symmetrie des Poissons Pleuronectes dans la jeune age. Annales des Sciences Naturelles, 3me séries, xx. pp. 340–342.

Donovan is said to have mistaken one of these abnormally developed specimens for a new species, and to have called it *Pleuronectes cyclops.*

In the summer of 1863, I myself obtained, in dredging over a sandy bottom in the Firth of Forth, three young Pleuronectidæ, each about half an inch long, and apparently belonging to the genus Platessa. In all but one, the eyes and dorsal fin were conformed exactly as in an adult flounder, but the remaining one, which I have the pleasure of exhibiting to the Society to-night, has one eye on the middle line of the top of the head, with, as in M. Van Beneden's specimen, the dorsal fin stopping short behind it.

As regards the imperfectly developed or monstrous flat fishes already referred to, I am enabled to exhibit to you to-night a specimen of a turbot presenting the peculiar condition of the eyes and cephalic extremity of the dorsal fin characteristic of those specimens. Through the kindness of Professor Goodsir, I have also had an opportunity of dissecting a similarly malformed flounder (*Platessa flesus*).

These malformations are flat fishes in which the turning round of the upper eye to the other side of the head has been arrested when it has got about the middle line of the top of the head; and in consequence the passage forwards, and tying down of the anterior part of the dorsal fin, has also been stopped, or obviously it would cross over the eye instead of passing by the side of it, as it ought to do. It accordingly projects upwards and forwards in a free pointed process, overhanging the eyes, as may be seen in the specimen on the table. It is worthy of remark that all these abnormal specimens are equally coloured on both sides, as if the animal, not having perfectly acquired the characteristics of a flat fish, swam with either of its sides upwards at pleasure, or it might be that it swam, not on its side, but with its mesial plane vertical, as in an ordinary fish. In the specimen on the table, it will also be observed that not only are both sides coloured, but that the rough bony tubercles, usually characteristic only of the ocular side of the turbot, are here also equally abundantly distributed on the opposite one.

I may add that the result of my own examination of the structure of the pleuronect head is in entire harmony with the above view of the nature and origin of the asymmetry of these animals. But M. Steenstrup has only a few months ago* revived the theory of Rosenthal, that the upper eye has passed through the head to the place it now occupies, and that this "migration" of one of the eyes has had a much more important share in bringing about the ocular transposition, than any slight twisting that may have taken place. According to his views, "the eye at an early age must have quitted its primitive position, and directing itself upwards and towards the anterior, pierced the vault of the cranium constituted above the eye by the frontal bone, and formed for itself a new orbit, whether on the internal region of the frontal bone of the same side, or between the two frontals." In support of this theory, he refers to the structure of several very interesting young pleuronectidæ about an inch long, brought from various localities in the Atlantic, and deposited in the Museum of Copenhagen. In one of these specimens, which seem for the most part to belong to the group of "Plagusiæ," the transposition seems never to have taken place at all, the eyes being disposed one on each side, that on one side being, however, slightly above the level of the other. But the specimen which most fully seems to justify M. Steenstrup's views, is one where the animal seems to have three eyes, the eye of one side projecting through a little fissure above that of the other side, which side thus becomes binocular.

This appearance is so very striking, that we need not wonder that M. Steenstrup remarks, "Can we imagine a more striking demonstration of the passage of the eye across the head than an eye arrested in that position?" Another speci-

* J. Japetus Sm. Steenstrup;—"Om Skjaevheden hos Flynderne, og navnlig om Vandringen af det övre Öie fra Blindsiden till Öiesiden tvers igjennend Hovedet." Kiöbenhavn, 1864. Saerskilt Aftryk af Oversigt over d. K. D. Vid. Selsk. Forhandl. i. Nov. 1863.

"Observations sur le Developpement des Pleuronectes," par M. Steenstrup. (Annales des Sciences Naturelles. Paris, Nov. 1864.)

The former of these two papers, being written in the Danish language, I have not yet read.

men described by him has one eye on each side, but above the left eye is a little slit where the other should appear.

In addition, M. Steenstrup remarks that the osteology of the head of the adult flat fish confirms his view of the process of ocular transposition in the embryo. Like Rosenthal he compares the head of a flat fish to that of a cyclopean malformation ; and affirms that the position in which we find the upper eye is not homologous with that occupied by the lower, nor with the orbit of any other fish or vertebrate animal in general. Here I will in the meanwhile only say that my own dissections have led to a very opposite conclusion, namely, that the upper eye of a flat fish is homologous in position with the lower one—that the bar of bone between the eyes is the only representative of the frontal arch in the symmetrical osseous fish, but altered in position, being pushed over to one side, and that the other bar of bone bounding the orbit and upper eye on the inner side is an entirely additional formation, developed from the frontal and prefrontal of the eyeless side, and not found in the plan of the ordinary fish head.

Although M. Steenstrup's observations are very remarkable, and not to be put aside simply because they do not tally with our preconceived notions, yet on the other hand I do not think that we can at present accept them implicitly as representing the normal process of development among all the Pleuronectidæ, especially seeing that they are in such direct opposition to the teachings of the structure of the adult pleuronect, both normal and malformed, and to the embryological observations, so far as they have gone, of other authors. M. Steenstrup's specimens may possibly be malformations of a nature essentially similar to those already referred to, but in which the dorsal fin may have actually bridged over the upper eye. Or there may be some groups of Pleuronectidæ, in which the upper eye in the normal course of development may become bridged over by the advancing dorsal fin, a slit being left through which afterwards the upper eye passes to its position on the binocular side of the fish. This is, however, mere theory ; meanwhile it is greatly to be desired that additional information be collected

regarding the early stages of the development of the Pleuronectidæ.

II. *Notice of the Cranium of a Manganya Negro, brought by Dr Kirk from East Tropical Africa.* By WILLIAM TURNER, M.B., F.R.S.E.

The cranium of the Manganya negro, to which I am about to direct the attention of the Society this evening, was given to me a short time ago by Dr John Kirk, the enterprising and experienced African traveller, the friend and companion of Livingstone in his last expedition. To this able and accomplished naturalist science is indebted for many valuable observations and discoveries of new facts illustrating the natural history of East Tropical Africa. Amongst the objects which he has brought to this country are several crania of the Manganya tribe of negroes, a people in whose country Kirk and Livingstone travelled for a considerable period. When they first visited them, they found a large and important tribe living on the banks of the river Shire, in lat. 16° S., and long. 35° W. Dr Kirk tells me that they may be taken as a good type of the natives of the North Zambesi region, and of the lake Nyassa, or southern lake. The Manganya, as they call themselves, or the Wanyassa, as they are named by the slave-dealers of Ibo and Zanzibar, must not be confounded with the Zulus of the South, or the Makoa of Mozambique, but are almost identical with the Maravi mentioned in Gamitto. The hair is crisp and woolly, but abundant; the colour of the skin is sepia; the stature is commonly under that of the English.

In an interesting address delivered before the Members of the British Association at the meeting in Bath in 1864, Dr Livingstone described the country of the Manganya, and gave many interesting facts connected with their habits. They were a people who cultivated the soil, were very eager traders, and were so far advanced in the useful arts, that near many of the villages furnaces were erected for smelting iron from the ore, and excellent hoes were made cheap. The country was thriving and prosperous when Kirk and Livingstone first entered it, but soon afterwards the slave-

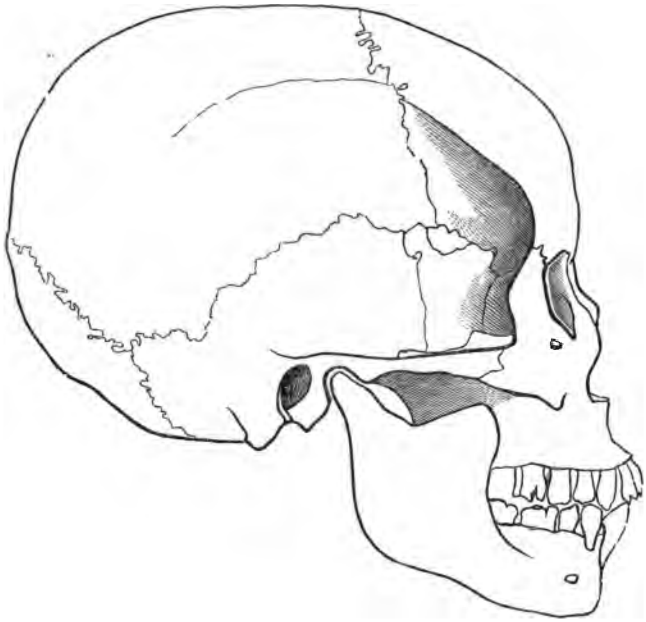
traders attacked the people, murdered the males, and carried the women and children captive. To quote Dr Livingstone — "The Shire Valley, where thousands lived at our first visit, was now converted into a valley of dry bones. One cannot now walk a mile without seeing a human skeleton, or open a hut in the now deserted villages without seeing the unburied skeletons lying there."

Of the crania of these people which Dr Kirk brought with him, five specimens are deposited in the Hunterian Museum, London; a sixth is the one now exhibited to the Society.

From the general appearance of the skull—from the open condition of the cranial sutures, more especially the want of ossification of the basi-cranial synchondrosis—from the perfect state of the teeth which are erupted—from the third pair of molars in the lower jaw being completely concealed within their alveoli—and from the corresponding teeth in the upper jaw only beginning to protrude—the skull is evidently that of a youth, probably of one not more than 18 years of age. The sex, as the filed condition of the incisor teeth indicates, is the male. The skull, in some of its features, affords an illustration of some of the characters of the negro cranium: the nasal region is broad and flattened, the breadth being about equally divided between the nasals and ascending processes of the superior maxillæ;* the nasal orifice is large, and approaches the quadrilateral in form; the upper jaw projects strongly forward in the region of the incisive teeth, and the prognathism is still further increased by the downward and forward slope of these teeth. In the frontal region there is an almost complete want of supra-orbital ridges and glabella, and the ascending part of the frontal bone, instead of at once sloping backwards, passes at first almost vertically upwards, and affords space for the development of the frontal lobes of the brain. The parietal region is well formed, and slopes somewhat abruptly downwards pos-

* The relative proportion in which the nasals and superior maxillæ contribute to the production of the broad flattened nose of the negro, varies considerably in the crania of different individuals. In some the two nasals contribute much more than the superior maxillæ, whilst in others the former are reduced to the state of very narrow bars of bone.

teriorly into the supra-spinous region of the occiput. The skull possesses a well-marked oval form. The muscular ridges and prominences are not very strongly pronounced, and the cranial bones possess none of that coarseness and thickness which are so often regarded as characteristic of the negro skull. In its internal capacity the skull measures 79 cubic inches, which is somewhat below the mean of 83 cubic inches given by Dr Morton as the average capacity of the negro crania he had examined. The following are some of the principal external dimensions of the skull, expressed in

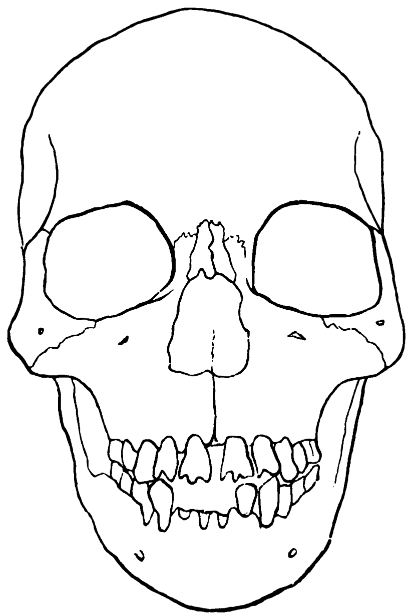


Manganya Skull—Fig. 1.

inches and tenths:—Extreme length, 6·7; breadth (parietal), 5·0; height, 5·2. Greatest frontal breadth, 4·2; parietal, 5·0; occipital, 3·8; zygomatic, 4·7. Fronto-nasal radius, 3·5; maxillary, 3·9; frontal, 4·3; parietal, 4·7; occipital, 3·4. Longitudinal arc, 14·0; frontal, 5·0; parietal, 5·0; occipital, 4·0. Frontal transverse arc, 11·1; parietal, 12·8; occipital, 10·0. Horizontal circumference, 19·0. The ratio of length to breadth is 100 to 75; of length to height, 100

to 77. In these dimensions of length, height, and circumference, the skull is somewhat within those given by Mr Busk as the mean in the intratropical negro. But the small size of the cranium, and the absence of any strongly-marked lines and ridges, are probably, in part at least, due to the youth of the individual from whom it had been obtained.

The teeth, in the upper jaw more especially, present some features of interest. Throughout the series, but more strongly marked in the incisive region, the intervals be-



Manganya Skull—Fig. 2.

tween the different teeth are much greater than one is accustomed to see in the human skull, amounting to as much as the tenth of an inch, but it must be noted that the diastema between the canine and lateral incisor is not greater than that between the lateral and central, or the two central incisors; and in this respect it presents an important difference from that which gives so characteristic a feature to the dental series in the ape, in which the diastema

between the canine and lateral incisor is much greater than the intervals between any of the other teeth. The central incisors are also considerably larger than the lateral. They all present, at their cutting edges, a serrated appearance, evidently produced artificially by filing, the central incisors exhibiting three denticulations, the lateral only two. Although the file has passed for some depth into the substance of the crown, yet the enamel, from its thickness, has scarcely been abraded sufficiently at the bottom of the notch to expose the dentine. (See figs. 1 and 2.)

The practice of artificially interfering with the incisive teeth is one which prevails amongst various savage races in different parts of the world, but more especially amongst many tribes of negroes. In some, as in the case before us, it is the custom to give to the cutting edge a serrated appearance; in others, as in the people of Unyamuezi, described by Captains Speke and Grant, the lower incisors are more or less extracted, and a deltoid-shaped fissure is cut between their two upper central incisors. Winterbottom, again, describes some of the negro tribes as filing their teeth, so as to make them conical and sharp-pointed; whilst Livingstone states that both sexes amongst the Batoka negroes, a tribe living near the Victoria Falls on the Zambesi river, knock out the upper front teeth at the age of puberty, but leave the under teeth in their place. Amongst the Mangȧnyas Dr Kirk tells me the practice of filing the upper incisors is confined to the male sex.

In the lower jaw of the skull of this Manganya negro, only the left lateral incisor is in its socket, the rest having unfortunately dropped out of their alveoli, but it exhibits no marks of the file. The canine teeth are somewhat remarkably shaped at the cutting edge, where they exhibit a prominent central tubercle, with two faintly-marked lateral elevations. The intervals between the different teeth, though very perceptible, are yet scarcely so strongly pronounced as in the upper jaw. The vertical and antero-posterior diameters of the ascending ramus are almost equal. The horizontal ramus is comparatively feeble, except at the symphysis, which possesses a fairly-marked chin.

III. (1.) *Notice of a Species of Pipe Fish of the genus* Doryichthys, Kaup., *probably new, recently brought from Old Calabar.* By John Alexander Smith, M.D. (Specimen exhibited.)

I am indebted to my friend Dr Hewan, who is now present, for various specimens of natural history which he has recently brought with him from Old Calabar. Of these, I will at present exhibit this small pipe fish, which seemed to belong to the genus *Doryichthys*, Kaup., and was probably a new and undescribed species; at least, I have been unable to find the description of any species which exactly corresponded with it; and the pipe fish of Western Africa are, I believe, as yet but very imperfectly known.

The body is deeper than broad; hexangular (including projection of lateral line) to beyond anus and base of tail as far as the dorsal fin extends; beyond this the tail is quadrangular. Snout slightly spotted with black, perfectly smooth on its edges and sides, with three faint lines along its upper surface,—a central line, and one from front of each orbit running above nostrils; these lateral lines are also produced backwards to occiput; a fainter line from below orbit and nostril joins the lateral lines in front. A raised central line runs backwards along occiput and centre of first two rings of body. Another raised line also runs horizontally across middle of operculum (which is continued across first segment of body), with two fainter oblique lines below, running up to the front of this horizontal line.

Body of 22 rings or divisions.

Tail of 24 do. do.

19 rings before dorsal fin.

Dorsal fin placed apparently on 9 rings, 3 of which belong to the body.

Lateral line distinct, turns down by an arc to join the lower edge of tail, and a short interrupted lateral line beyond this arc, curves gently upwards, and joins the upper edge of tail at the posterior termination of the dorsal fin.

Edges of back and lateral line serrated, so as to catch finger when drawn towards the head; each ring having a spinous projection a little within its distal margin, longer in posterior rings or segments.

A faint line also projects along the centre of the two first segments of body, on the abdominal surface; this surface has two lateral free projecting membranes or plates, which rise at the third ring of body, and run along its whole length on each side, and between them, in this specimen, are numerous distinct and naked ova.

Pectoral fins short and broad, about $\frac{2}{20}$ of an inch in length by $\frac{2}{20}$ of an inch in breadth at base; of 19 fin rays.

Dorsal fin long and low; number of fin rays indistinct and uncertain.

Anal very small, apparently of 3 or 4 rays; indistinct, situated at termination of projecting lateral membranes.

Caudal fin $\frac{4}{20}$ of an inch in length, with 5 or 6 rays.

The *colour* of the fish, which has apparently been first dried, and then put into spirits, is bronze or golden brown, especially brilliant on the snout or operculum.

Length of body from point of snout, $2\frac{10}{20}$ inches.

Length of tail, $1\frac{15}{20}$ inch.

Total length of fish, $4\frac{5}{20}$ inches.

Length of head, $\frac{17}{20}$ of an inch.

Length of snout in front of orbit, rather less than $\frac{11}{20}$ of an inch.

Length from front of orbit to back part of operculum, rather more than $\frac{6}{20}$ of an inch.

The fish was believed to have been taken in the lower part of the Old Calabar River, Western Africa.*

(2.) *Notes of two Specimens of the* Chameleo cristatus (Stuch), *the Fringed or Crested Chameleon, from Old Calabar.* By JOHN ALEX. SMITH, M.D. (Specimens exhibited.)

This species was easily distinguished from all other chameleons by the presence of a large, erect, fin-like crest, supported by bony rays, which ran along its back and the base of its tail. It was first discovered at the Gaboon in 1834, and had since been observed at Fernando Po, and latterly at Old Calabar.

The general colour of the specimens, preserved in spirits, is brownish or greyish brown above, with darker and lighter

* Dr Smith has since placed the specimen, for determination, in the hands of Dr Günther of the British Museum, our first authority in Ichthyology.

spots; below, and inside the legs, the colour is lighter or dirty white, which is also more abundant over the base of tail, and back parts of the body.

In the first specimen, the crest is spotted all over with dark-grey or brown; in the second this is less distinct, but a darker band runs along its base. The scales of the body are small, with scattered larger ones over the body. The scales of the legs are small, and equal in size.

In both specimens the top of the head is spotted with black and dirty white; and in the first, the top of occipital crest is blunt; there are two small oval-shaped spots of a light colour, with a darker border and bar between them, side by side on the front of the muzzle, above nostrils. In the second specimen these spots are dark-coloured and their edges lighter, and its occipital crest is pointed above; the base of the tail is the thickest in this specimen, the enlargement gradually tapering backwards, and extends from the anus along the tail for about $\frac{3}{4}$ of an inch; the first being probably a male, and the second a female. The tail is also rather longer; in both specimens the tail is comparatively short, and tapers rapidly to a point. The chin and neck are destitute of any crest; a faint crest, however, consisting of slightly raised and pointed tubercles or scales, commences below and between the anterior extremities, and terminates at the anal opening.

Admeasurements of specimens:—

	1st Specimen. inches.	2d Specimen. inches.
Length of body from point of snout to anal opening, ...	$4\frac{1}{2}$	$4\frac{1}{2}$
Length from anus to point of tail, . .	$3\frac{1}{4}$	$3\frac{3}{4}$
Total length, ...	$7\frac{3}{4}$	$8\frac{1}{4}$
Greatest breadth of body, including crest of $\frac{3}{8}$ in.	$1\frac{3}{4}$	$1\frac{3}{4}$
Greatest breadth of crest at shoulder, .	$\frac{1}{2}$	
Length of head from snout to point of occipital crest, ...	$1\frac{1}{8}$	$1\frac{3}{8}$
Greatest breadth of top of head between orbits,	$\frac{1}{2}$	$\frac{1}{2}$
In dorsal crest:—		
Dorsal spinous processes in number, .	16	16
Caudal, ...	9	10

In the first specimen, beyond the nine caudal spines, there

are a few short spines which cannot be easily counted, forming a low ridge, which gradually diminishes towards the rounded extremity and point of the tail.

In the second, the last of the caudal spines numbered diminish towards the rounded extremity of the tapering tail, which measures about 2½ inches or so in length. The crest extends for nearly 5 inches, from behind the occiput to about 1⅛ inch beyond the anal opening. I have the pleasure of presenting the specimens to our Museum of Science and Art, which has none of this rare chameleon.

Wednesday, February 22, 1865.—DAVID PAGE, Esq., President, in the Chair.

The following Donations to the Library were laid on the table, and thanks were voted to the Donors:—

1. (1) Transactions of the Zoological Society of London. Vol. v. Parts 1 and 2, 1862-63; (2) Proceedings of the Zoological Society of London, 1862, Parts 1, 2, and 3, January-December—From the Society. 2. Transactions of the Botanical Society of Edinburgh. Vol. viii. Part 1, 1864. 3. Transactions of the Royal Scottish Society of Arts. Vol. vi. Part 4, 1864.

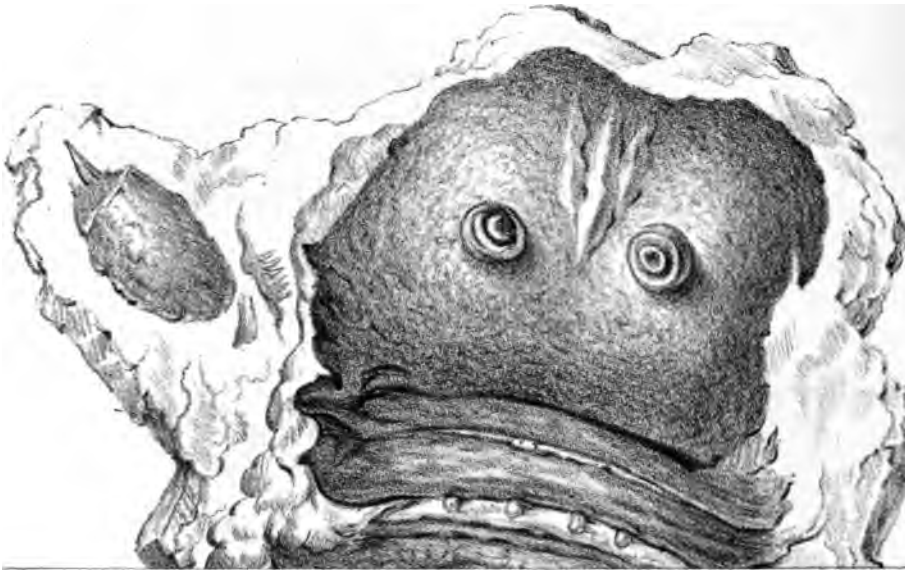
The following Communications were read:—

I. *Notes on the Crustacean genus* Stylonurus; *from the Lower Old Red Sandstone of Forfarshire.* By DAVID PAGE, Esq. (Plate III.)

Mr Page gave a brief description of the genus *Stylonurus,* alluding more especially to a new and gigantic species that had been recently discovered in the flagstones or lower Old Red Sandstone of Forfarshire. He had established the genus in 1855, from a specimen obtained from the Forfar flagstones by Mr Powrie of Reswallie, to whom the Society owed the exhibition of the beautiful casts now on the table. The genus he had named from the pointed style-like tail-plate, which at first sight formed the most obvious distinction between it and the allied genera *Eurypterus* and *Pterygotus.* The whole belonged to the fossil family *Euryp-*

PLATE III.

Vol. III. *Royal Physical Society, Edinburgh*



teridæ, the members of which were distinguished (*in the dorsal aspect*) by their rounded or sub-quadrate carapaces or head-plates, with central, sub-central, or marginal eyes; by their lobster-like thoracico-abdominal segments, twelve in number, and void of appendages; and by their single-pieced telsons or tail-plates, which were oval and pointed, heart-shaped, or long and style-shaped, as in the genus now under review. The carapaces (*in the oral or ventral aspect*) were furnished with four pairs of five or six jointed members—the three first variously formed in the different genera (some armed with spines, others with prehensile pincers), and the posterior pair forming the broad, oar-like swimming feet, which had given the name to the family. The oral apparatus consisted, as in the King-crab, of the serrated basal joints of the limbs, and was protected by a broad heart-shaped metastome or mouthpiece. The genital and anal orifice occurred in the first thoracic segment, and differed, both in situation and appendages, from all known crustacea. In all the genera the exterior crust was ornamented by a peculiar scale-like sculpture, which became bolder and stronger on the free or exposed margins of the respective segments, and in several of the species passed into a peculiar serrated or bead-like ornamentation.

The *Eurypteridæ* ranged in time from the Upper Silurian to the Carboniferous limestone inclusive, and some of them were of gigantic dimensions—the Forfarshire *Pterygoti* and *Stylonuri* often ranging from four to six feet in length, and in other parts of corresponding dimensions. The first *Stylonurus* discovered was *S. Powriei*, distinguished by its very rounded carapace, central eyes, long, pointed, and perhaps caniculated tail-plate, and by its swimming limbs, which, instead of being paddle-shaped as in *Pterygotus*, were long, narrow, and ensiform. This species had two pairs of similar swimming limbs; the anterior limbs had not been preserved, and were accordingly unknown. It had yet been found chiefly in the lower Old Red Sandstone of Forfarshire, and specimens indicated its dimensions as varying from eight to eighteen inches in length. The next species, *S. spinipes*, had been discovered in the "Passage-

beds" of Upper Lanarkshire, in 1857, by Dr Slimon of Lesmahagow, and was a smaller and more slender species than the preceding. It had the same general aspect, but had the carapace more quadrate, the eyes less central, and the two first pairs of limbs armed with spines at the joints, hence the name which Mr Page had given it in 1858. Fragments of *S. Powriei* had been found in the lowermost Old Red of Lanark; but in these, as in the Forfar specimens, the characters were distinct from those of *S. spinipes*, as might be seen from the casts now before the Society. The third species, *S. armatus* (see Plate III.), had been obtained by Mr Powrie from the Forfar flagstones in 1863, and was distinguished from the two preceding by its greater size, shorter carapace, shorter and broader swimming limbs, and by the bold lateral processes (epimeral processes?) of its abdominal segments, from which the name *armatus* had been suggested. The length of this specimen, when entire, as might be seen from the cast, was 3 feet 6 inches, but, though exceeding the other species in this respect, it fell far short of species of *Pterygoti* from the same formation.

The beautiful casts and drawings before the Society, and the account Mr Page had formerly given of the Eurypterite family, rendered further description on this occasion unnecessary. He had seen fragments both from the Lanark and Pentland Passage-beds and the Forfar Old Red, which appeared to belong to other species of *Stylonurus;* but as sculpturing, size, and form of appendages, might be indicative of age or of sex, as well as of species, he thought it unwise to cumber the science with doubtful and provisional species, and contented himself, in the meantime, with merely noting the fact of the occurrence of these fragments, which consisted of detached limbs, abdominal segments, and tail-plates. So far as was known at present, the Eurypterites occurring in the upper Silurian and lower Old Red of Scotland were restricted to the genera *Eurypterus*, *Pterygotus*, *Slimonia*, *Stylonurus*, and *Crossopterus;* and those in the lower Coal Measures to *Eurypterus* (the *Eidothea* of Scoular), which had yet been found only in the lower limestones of Bathgate and Burntisland.

II. *On the Animal and Vegetable Life in the Water of Leith, &c.* By Dr Stevenson Macadam, F.R.S.E.

In the bed of the Water of Leith above the influence of the sewage of Edinburgh, as at Gorgie dam, which is about a mile above Coltbridge, the stones over which the water flows have plants, such as moss, attached to them, and these plants are found on the stones in the bed of the streams conveying water practically free from putrescent matter; but from the entrance of the Edinburgh sewage at Coltbridge downwards to the harbour of Leith, the stones in the bed of the stream are covered with offensive organic growths, which are characteristic of waters conveying sewage and capable of decomposing and evolving unwholesome gases. Indeed, not only are the stones covered with such vegetable growths, but everything in the bed of the river, such as arrested portions of trees, become thickly coated. They are also seen in the sewers called the Lochrin Burn sewer, the Broughton Burn, and the Bull's Stank sewer at Lovers' Loan as it leaves Edinburgh, in all of which the bottom and sides are more or less covered with the growths. Even in the narrowed part of the channel of the Water of Leith, where the run of water is great, these organic matters are abundant, and likewise in the bottom and sides of the lade which traverses Edinburgh. All the twigs and branches of trees which hang down into the Lochrin Burn sewer, and into the water of the lade, as from the gardens behind Anslie Place and Moray Place, have these growths adhering in long streamers, rendered bulky and doubly foul by the accumulation of entangled filth. These growths principally consist of those low forms of vegetable life which are regarded by some naturalists as *Fungi*, and by others as *Algæ*, and they are accompanied by masses of animals belonging to the family of *Vorticellidæ*, including the genera *Vorticella*, *Carchesium*, *Zoothamnium*, and *Epistylis*. Much of the organic matters which are found entangled in the branches of trees hanging into the lades and open sewers, as also of the organic deposits which are found in the beds of the Water of Leith and of the lades, are composed of the decaying remains of such growths.

The chemical analyses of these organic growths demonstrated, that even when examined with all the adhering entangled filth, when dried, they contained, on the average of seven samples, 50·61 per cent. of organic matter, of which 0·84 consisted of nitrogen. These organic matters are being constantly detached from the stones, &c., on which they grow, and the torn-off fragments float down the stream or lade and form part of some deposit in a rocky pool or in the still water above a dam or call. A considerable proportion of the deposits observed in the bed of the Water of Leith behind Ainslie Place and Moray Place, and in the large cesspool at St Mark's Place, consisted of those organic growths passing into an active state of putrescence. During the spring months the growths are apparently stronger, and form longer streamers than during the summer months. The temperature of the latter is higher, and facilitates changes such as the disintegration of the mass. These growths appear to be the last stage of organic life which will inhabit foul water, but in places where in the spring many patches of the growth were observed, in summer hardly any was to be noticed. This disappearance, in part at least, of the growth is attributed to the more foul state of the sewers and Water of Leith in summer, which leads in some places to such a rapid putrefaction as even to arrest the development of this comparatively simple form of organic life.

In the whole course of the Water of Leith from Coltbridge downwards not a single fish could be seen. The animal life which was specially visible to the naked eye consisted of colonies of small red worms, which were very abundant in many places, and are regarded as the last remnant of animal life which will exist in water contaminated by sewage. These minute red worms are a kind of *Nais*, belonging to the family of *Naidina*, and are named *Tubifex rivulorum*. They are found in greater abundance in the Water of Leith during spring than in summer, apparently from the more active putrescence of the sedimentary matter leading in the summer to the disengagement of a more full supply of noxious gases, which even these minute worms cannot survive. In many places, where in spring the bed of the

stream or of the lade harboured myriads of even this inferior type of animal life, there was hardly a specimen to be had, and this was doubtless due to the more rapid putrescence of the deposits. Abundance of animalculæ, including the *Paramœcia*, were found in the Water of Leith at all seasons of the year.

One curious effect of sewage upon animal life was observed by me in the harbour of Leith. Two wooden piers stretch some distance into the sea; they are constructed of the same kind of timber, and are of the same age. The west pier is not liable to be influenced by sewage passing down the harbour, as the tide sweeps the sewage from it, and the wood of this pier is nearly eaten through in some parts by the *Teredo*, a bivalve (Lamellibranchiate) mollusc, which is well known to be destructive to wooden erections in the sea. But the east pier is washed by the sewage water, and apparently from the disengagement of sulphuretted hydrogen, which is specially formed when sewage meets sea water, there is not a single *Teredo* to be seen at its work of drilling holes in the wood. The sewage in such circumstances therefore appears to be beneficial in retarding the ravages of this troublesome mollusc.

Independently of the putrefaction of the sedimentary deposits, fish might live in water which contained nearly the proper proportion of oxygen, but the water of the Water of Leith from Coltbridge downwards is almost devoid of oxygen, and fish can no more live in water containing no oxygen than land animals could live in an apartment destitute of air.

It is worthy of note, as evidence of the state of the Water of Leith, and its incapacity to support the life of fish, that during the summer of 1864 a shoal of young herrings attempted to enter the harbour of Leith, and those herrings turned over on account of the foulness of the water, and the majority died upon the spot.

During the progress of these observations, attention was directed to a green substance consisting mainly of *Euglena viridis*, one of the Phytozoa, which was observed on the surface of the stagnating mud at the side of the Lochrin Burn,

and in shallow parts of the Water of Leith, as at St Mark's Place, and which was said *to neutralise in great part the deleterious effects of the gaseous exhalations, and even to lead to the disengagement of oxygen gas in large volumes.* A considerable quantity of the green slime was separated as well as practicable from the underlying filthy sediment, and having been placed in a bottle till it was filled, the bottle was then inverted in a basin, and immediately gases began to be evolved. On testing these gases in about three hours, there were found carbonic acid 13·40 per cent., oxygen 1·60 per cent., and other gases, which were combustible with a bluish-white flame, 85 per cent. It was proved, therefore, that this green slime does not practically lead to the disengagement of oxygen, and indeed the gases which are evolved therefrom are essentially identical with those obtained from any foul deposit in a sewer or in water conveying sewage.

Moreover, the green slime, when collected from the surface of the sedimentary matter, and placed in a bottle which it filled about one-third, and the remaining two-thirds being left as common air, it was found that in forty hours the composition of the atmosphere had so materially changed, that a lighted taper was immediately extinguished on being introduced. A chemical analysis proved that the atmosphere left in the bottle contained 11·56 per cent. of carbonic acid, only 2·01 per cent. of oxygen, and 86·43 per cent. of other gases, which in their mixed state were not combustible, and did not support combustion. These two experiments, therefore, demonstrated that practically the evolution of oxygen gas from the green slime covering a mass of putrescent filth was at a minimum, and was highly problematical, whilst the disengagement from the mass of carbonic acid and of combustible gases was undoubtedly certain. The green slime, on being examined microscopically, was found to consist mainly of minute organisms belonging to the *Phytozoa*, and which are alternately regarded as animals and plants. At present, the *Euglena viridis*, which forms a part at least of the green matter of these deposits, is considered to be a plant by some naturalists, and an animal by other authorities.

III. *On the Natural History of* Euglena. By T. STRETHILL WRIGHT, M.D.

Dr Wright stated that as far as concerned the *Euglenas,* which Dr Macadam had found in the Water of Leith, it was at present the general opinion of naturalists that these organisms belonged to the Phytozoa, and, like plants, were attracted by light, and gave off oxygen gas. He stated that chlorophyll, or the green colouring matter of leaves, was found to exist largely in them. This chlorophyll, however, was found by Angstroon, who had examined it by spectrum analysis, to be identical with that contained in confervæ and other green algæ, but different from the chlorophyll of phanerogamic plants. Dr Wright then gave a sketch of the physiology of *Euglena.*

IV. *A Specimen of the Smew,* Mergus albellus, *shot in Haddingtonshire, was exhibited by* JOHN ALEX. SMITH, M.D.

The Smew, a fine adult male, was shot at Tynningham in the first week of February. Its stomach was found to be filled with minnows. Dr Smith was indebted to Mr Small, George Street, for exhibiting the specimen. Some four years ago another specimen of this rare visitor was shot in the month of January in the same locality.

Wednesday, March 22, 1865.—DAVID PAGE, Esq., President, in the Chair.

The following Donations to the Library were laid on the table, and thanks voted to the Donors:—

1. Proceedings of the Royal Society, London. Vol. XIII. Nos. 69 and 70, 1864.—From the Royal Society. 2. (1.) On the Presumption of Survivorship; (2.) On the Relations, Structure, and Function of the Valves of the Vascular System in Vertebrata.—By James Bell Pettigrew, M.D., Edinburgh.—From the Author. 3. The Canadian Journal of Industry, Science, and Art, New Series, No. 54, November 1864.—From the Canadian Institute, Toronto. 4. Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt, 1864. XIV. Band, Nro. 1. Jan., Feb., Mar.—From the I. R. Geological Society of Austria. 5. (1.) Transactions of the Royal Society of Edinburgh. Vol. XXIII. Part 3, Session 1863-64; (2.) Proceedings of the Royal Society of Edinburgh. Session 1863–64. – From the Society.

I. *On the Natural Agencies at present in operation, to which the Phenomena of the Glacial Epoch may be ascribed.* By the Rev. James Brodie, Monimail, Fife.

Of all the discoveries which geologists have made, there are none that have excited greater interest, or given rise to more varied discussion, than those which relate to the glacial epoch.

Confining our view to the British Islands, we find that, after the lapse of many ages, during which the temperature seems to have been as warm, or even warmer, than that which now prevails, the country had been subjected for a lengthened period to all the rigours of a polar climate. This severity of climate had again been gradually ameliorated, till at last it gave place to the equable warmth which we now enjoy.

We need not, therefore, wonder that a lively interest has been excited in the various endeavours that have been made to discover the causes to which these phenomena are to be attributed.

In the following observations, it is our object to show that the changes to which we have alluded may all be explained by a reference to the varying effect of the natural agencies by which the solar heat, communicated to the intertropical regions, is afterwards distributed over the earth; and we hope, by a little careful consideration, to establish the accuracy of our views.

These agencies are three in numbers—I. The air which covers the land; II. The air that covers the sea; and III. The surface water of the ocean.

I. The *first* of the natural agencies by which the equatorial heat is distributed over the globe, is that of the air which covers the land within the torrid zone.

A part of the heat communicated to the intertropical lands passes by radiation into space. Another part is communicated by contact to the air which lies above them. This latter part we know to be very considerable, though it is difficult to determine the proportion it bears to that which is given off by radiation. The air, thus warmed and

rarified, rises upwards and flows towards the poles, where it mitigates the severity of the polar circles. To the aerial currents thus produced, and modified by various causes, the prevailing winds that agitate our atmosphere are usually ascribed.

As there is nothing to interrupt those currents, their influence continues from age to age unchanged. We cannot, therefore, regard them as having any effect in producing the phenomena which are peculiar to the glacial epoch.

II. The *second* natural agency, by which the heat communicated to the equatorial parts of the globe is distributed over the earth, is the air lying above the intertropical seas; which, after being warmed and saturated with moisture, is carried, like the air lying above the land, towards the poles.

In consequence of the water of the equatorial oceans absorbing a large portion of the solar influence, the air which lies above them has not so large an amount of heat communicated to it as that which is imparted to the air which covers the land. This is proved by the well-known fact, that within the tropics the breeze from the land is warm, while that which comes from the sea is comparatively cool. When transferred, therefore, to the polar circles, its effect on the temperature is less than that of the aerial currents from the land, but it is an effect of a precisely similar kind.

This warm air from the ocean differs also from that which is heated by contact with the land, in having a much larger quantity of moisture diffused through it. Some have conluded that, in consequence of this admixture, its influence on the polar regions is of an altogether different kind. The deposition of moisture, more especially in the form of hoar-frost or snow, is so generally associated with cold, that they have been tempted to regard it as that which produces the cold. In doing so, however, they mistake the effect for the cause. The fall of the snow is not the originating source of the winter's severity; but is the consequence and evidence of the freezing temperature that exists in the atmosphere.

There is no fact in science better established than that heat is absorbed when water is transformed into vapour,

whether that vapour occupies a chamber by itself in the form of steam, or is diffused through the air. It is equally well known, that heated air, whether it be moist or dry, produces warmth; and it is therefore evident to any one who reflects on the subject, that the warm vapour raised from the equatorial oceans, and carried to the poles, must contribute, in a greater or less degree, to elevate the temperature of the Arctic regions.

In a lecture delivered at the Royal Institution, and published in the "Reader" in February 1864, as "a contribution of great suggestiveness," Professor Frankland advocates a very different theory. He maintains that "the sole cause of the phenomena of the glacial epoch was a higher temperature of the ocean than that which obtains at present." In supporting this view, he assumes that the effects of the glacial period were felt over the entire globe; that it was preceded by a period of indefinite duration, in which glacial action was altogether awanting, or was at least comparatively insignificant; and that, in the course of the gradual cooling of the earth, the land had cooled more rapidly than the sea. He afterwards adduces some experiments, by which he endeavours to show that heat is more rapidly radiated from watery vapour than from dry air of equal temperature, and that the interposition of vapour diminishes the radiation from the surface of water much more than that from granite. He then proceeds to argue that the watery exhalations from a tepid ocean, condensed by the rapid radiation from the polar circles, produced the remarkable cold of the glacial epoch.

In his address to the British Association at Bath, Sir C. Lyell speaks of warm moist air from the south producing cold in the north, as if that were an opinion that is generally entertained by geologists. In referring to the influence of the sirocco, or wind from the desert of Africa, in melting the snows of the Alps, he adduces arguments which show that that desert had in the post-tertiary period been covered with the deep. He then goes on, without any reasoning in support of his statement, to say—"What mighty effects may we not imagine the submergence of the Sahara to have pro-

duced in adding to the size of the Alpine glaciers? . . . . The action of the south wind was not in abeyance, but its character was entirely different, and of an opposite nature. Instead of passing over a parched and scorching desert, it would plentifully absorb moisture from a sea many hundred miles wide, and when after complete saturation it struck the Alps, it would be driven up into the higher and more rarified regions of the atmosphere. Then the aerial current, as fast as it was cooled, would discharge its aqueous burden in the form of snow, so that the same wind, which is now called 'the devourer of ice,' would become its principal feeder."

Notwithstanding the deference due to men of such high reputation, we must say that we cannot adopt their views. We are not prepared to admit the assumptions which Professor Frankland makes, and we question the accuracy of the conclusions which he draws from his experiments; but even though we should take them all for granted, we cannot agree in supposing that the watery exhalations from a tepid ocean would produce cold in the regions to which they were carried. The principles that regulate the radiation of heat may not perhaps be very fully understood; but it certainly seems a very strange idea to suppose that the radiation of heat from moist air so vastly exceeds that from dry air, that while a current of the one produces a genial warmth, a current of the other is the cause of glacial cold.

In such a condition of the earth and sea as Professor Frankland supposes, there would, no doubt, be a far greater amount of moisture carried from the equator to the pole, but there would, at the same time, be along with it a much larger amount of heat, and that heat must have tended, not to increase, but to diminish the intensity of the cold.

Instead of entering into an elaborate refutation of his suppositions and arguments, we need only refer to the well-known fact, that the wind from the south-west, which follows the course of the Gulf-Stream, comes to our shores, at the present day, in precisely the same condition as that which Professor Frankland assigns to the aerial eurrents of the glacial period, and which Sir C. Lyell ascribes to the sirocco

of the post-tertiary epoch. That western breeze, as is well known, though it brings a superabundance of moisture to the districts exposed to its influence, does not bring "glacial cold." The south-western counties of England and Ireland are *not* colder than those on the eastern shore; but, on the contrary, are much warmer.

We therefore conclude that the air lying above the intertropical oceans, saturated though it be with moisture, when conveyed to the higher latitudes, produces an effect the same in kind, though less in degree, as that of the air which is heated by contact with the land. The currents which it forms, like those from the land, with which they intermingle, flow in their northward or southward courses without hindrance, and, in so far as we can judge, without change. They cannot, therefore, be regarded as having produced the phenomena that constitute the peculiarities of the glacial epoch.

III. The *third* of the natural agencies, by which the equatorial heat is distributed over the earth, is that of the surface water of the intertropical seas.

Those parts of the torrid zone which are covered with the deep receive the same amount of solar heat as those that are occupied by the land. This heat, however, is not communicated to the air that lies above them, in the same manner, and in the same proportion, as that which falls on the land is communicated to the air that covers it. Some of the heat falling on the ocean, like that which falls on the solid earth, is lost by radiation into space. There is also a portion communicated to the air, to which we have already referred; but the larger portion is expended in warming the water at the surface. The water thus heated becomes expanded, and consequently lighter than that which occupies the depths below; and, like the air in contact with the intertropical land, it flows northward and southward to the poles.

The effects produced by these warm oceanic currents are familiarly known, though the laws which regulate them, and the courses which they follow, have not been fully investigated. The Gulf-Stream, for instance, on the coast of

America is caused by the water in the Gulf of Mexico, and adjacent parts of the Atlantic, flowing towards the Arctic Sea. It is afterwards deflected eastwards to Europe. By this means it imparts to the western shores of that continent, and more especially to the British Islands, an average temperature higher by many degrees than that which prevails in other countries under similar parallels of latitude.

While the influence of these currents tends, like that of the aerial ones we before referred to, to equalise the temperature of the various regions of the earth, there is this remarkable distinction to be observed between them,—the aerial currents are uniformly distributed over the colder zones, and their influence is generally diffused; the oceanic currents are limited by the channels in which they flow, and are consequently local in their effects.

In like manner, as there is nothing to interrupt the course of the heated air, the atmospheric currents continue from age to age unchanged; while those alterations of relative level, which geology shows us to have been both frequent and great, may alter the channels of the deep, and divert the heated water now to one place and again to another, so that the same locality, which under its influence exhibited the verdure of a temperate sphere, may, when that influence is removed, be subjected to the rigours of perpetual snow.

These conclusions so naturally flow from the acknowledged principles of mechanical philosophy, that we presume there are few who will hesitate to accept of them as correct.

In examining the different hypotheses that have been advanced on the subject, we find that which is described by Sir C. Lyell, in his "Principles of Geology," and originally brought forward in 1833, more especially entitled to our consideration. "Some," he says, "have been induced to infer that there never has been any interruption to the agency of the same uniform laws of change. The same assemblage of general causes, they conceive, may have been sufficient to produce, by their various combinations, the endless diversity of effects of which the shell of the earth has preserved the memorials; and, consistently with these principles, the re-

currence of analogous changes is expected by them in time to come. . . . . . The greater warmth that seems to have prevailed in some former periods of the world's history is not to be ascribed to a greater degree of heat in the globe itself, but to a different distribution of land and water. If we were to imagine all the land to be collected together in equatorial latitudes, and a few promontories only to project beyond the thirtieth parallel, would be undoubtedly to suppose an extreme result of geological change. But a mere approximation to such a state of things would be sufficient to cause a general elevation of temperature. If there were no arctic lands to chill the temperature and freeze the sea; if the absorption of the sun's rays was in no region impeded, even in winter, by a covering of snow, the mean heat of the earth's crust would augment, the water of lakes and rivers would be warmer in winter, and never chilled in summer by melting snow. A remarkable uniformity of climate would prevail amid the archipelagos of the temperate and polar oceans, where the tepid waters of equatorial currents would freely circulate. We might expect, in the summer of the great year, plants allied to genera now called tropical. Forms now confined to arctic and temperate regions would almost disappear; coral reefs would be prolonged again beyond the arctic circles, and droves of turtle might begin again to wander through regions now tenanted by the walrus and seal."

There are some parts of this hypothesis with which we cannot concur. In the first place, we cannot suppose it possible that the tepid waters of equatorial currents would freely circulate, at a time when, according to Sir Charles' theory, the torrid zone was almost entirely occupied by land. The amount of water warmed by the sun, and flowing to the higher latitudes, necessarily depends on the extent of watery surface that is exposed to the influence of the solar beam. If the torrid zone were almost entirely covered with land, as he supposes it to have been in the period of the earth's highest temperature, there could not possibly have been any of those equatorial currents of which he speaks as warming the archipelagos of the northern ocean.

We may farther remark, that when we consider the means by which the excess of heat in the intertropical regions is conveyed to the polar circles, as we find them in the existing cosmical arrangements, we are led to conclude that the *general* temperature of the earth's surface is in reality but little affected by the manner in which the land and water are distributed over it. The heat communicated to the land is carried off by currents of air; the heat communicated to the ocean is carried off by currents of water; and it matters but little what the medium of conveyance may be. If geologists, therefore, are correct in their conclusions with regard to the far higher average temperature of the earth in the earlier eras, that temperature cannot possibly be accounted for by any supposititious change in the distribution of land and water.

While, however, we cannot adopt the hypothesis which assumes that a change in the distribution of land and water may effect the mean, or average, temperature of the earth, and account for the phenomena of the earlier eras, we certainly believe that local changes of climate of a very remarkable kind may be attributed to that cause.

We also concur in the opinion, which Sir Charles elsewhere expresses, that the glacial period was not contemporaneous all over the globe; but that, while one part of the earth was subjected to extreme cold, other portions in similar latitudes enjoyed a genial warmth.

Having now examined the principles that regulate the distribution of the equatorial heat over the globe, and having shown, as we flatter ourselves is the case, that many of those changes of temperature which the western parts of Europe have undergone may be ascribed to alterations in the direction of oceanic currents, we now proceed to inquire if there are any circumstances that lead us to conclude that such has really been the case.

There is one remarkable fact, or rather class of facts, that confirms our conjecture. All the changes of temperature which have occurred in the glacial and more recent epochs have been coincident with changes of elevation. When the British Islands were sunk from 1000 to 1500 feet beneath

their present level, those parts which were not submerged were covered with glaciers, and destitute of animal life. At an after period, an upheaval of some 800 feet took place, and then we find the remains of a fauna such as now exists in the Arctic seas. A further elevation introduced the epoch when creatures, like the rein-deer and mammoth, fitted for living in an arctic climate, were intermingled with the animals that still inhabit the country. Again, another rise of the land, variously estimated at from 50 to 100 feet, introduced our present peculiarly temperate climate.*

We usually find, that the higher the elevation of the country, the greater is the cold; but here we remark, that in proportion to the rise of the land, there has been an increase of temperature. This induces the supposition that the sinking of the western coast of Europe, and the deepening of the adjoining ocean, had formed a channel, which, if we may so express ourselves, drew towards it the icy current from the polar sea, and that at an after-time this polar current was again directed into another course by the upheaval of the bottom of the ocean.

If contemporaneously with this deepening of the sea on the coasts of Europe, there was such a depression of the coasts of America as would direct the Gulf-stream up through Davis' Straits, or if there were any other alteration of the channels of the ocean, by which the two currents were kept distinct, a supposition by no means improbable, we would then find ample explanation of all the phenomena of the glacial period.

At present, the current from the equator meets and mingles with that from the pole. By this means, their distinctive characters are in a great measure obliterated. But if, by any cosmical arrangement, they were made to flow in separate channels, without intermixture, the chilling influence of the one, and the warming effects of the other, would be much more apparent. The districts that are at present subjected to the rigours of a frozen climate might then rejoice in the mildness and verdure of a tem-

* If there is any inaccuracy in these statements, we trust to the correction of the practical geologists in the meeting.

perate sphere; while the influence of an arctic stream, laden with islands of floating ice, might so chill the atmosphere of Western Europe, that our hills and valleys, now mantled with green, would be covered again with glaciers and perpetual snow.

If professor Frankland's assumption be correct; if, as he supposes, "the effects of the glacial period were felt all over the globe,—if it was preceded by a period of indefinite duration, in which glacial action was altogether awanting, or was at least comparatively insignificant," we must ascribe the phenomena of that epoch to some agency at present unknown; but if we adopt the opinion, held we believe by many geologists, that the glacial period was not contemporaneous all over the earth, the natural agencies at present in operation may, with the utmost probability, be regarded as having produced all the peculiar phenomena of that rigorous time.

We conclude by suggesting some questions for the consideration of practical geologists.

1. Are there any traces of glacial action, or other evidences of extreme cold, to be found among relics of formations preceding the pliocene?

2. Have we not reason to suspect that those strata which exhibit no trace of organic remains, and which some have looked on as proofs of a time when darkness and desolation spread over the globe, originated in the operation of the agencies we have been examining? Are they not the effects of the glacial influences of earlier times?

A conversation followed, in which the Rev. Thomas Brown, Mr David Page, Mr Catton, Dr M'Bain, and Mr W. Rhind took part; and a vote of thanks was given to the Rev. Mr Brodie for his interesting and suggestive communication.

I. *On the Action between the Material Molecules and the Etherial Medium, considered with reference to the Theory of the Refraction of Light in Crystallised or Isotropic Media.* By ALFRED R. CATTON, M.A., F.R.S.E., F.C.P.S., Fellow of St John's College, Cambridge, Official Assistant to the Professor of Natural Philosophy in the University of Edinburgh.

The object of this paper was principally to discuss the bearing of a number of well-known facts on certain theoretical views, which are indicated by the title of the paper, as to the influence which the material molecules exert on the propagation of light in crystallised or isotropic media.

Supposing the phenomena of light to be caused by the indefinitely small vibrations of a highly elastic medium pervading space, it is a simple problem to determine the motion of such a medium in space where matter does not exist, as in this case, the problem is reduced to the determination of the motion of a *homogeneous* elastic medium; for there can be no doubt that if matter were annihilated, the ether would be homogeneous throughout the universe.

On proceeding, however, to investigate the motion of the ether in crystals or isotropic media, the question immediately arises, whether in these cases the ether may be treated as a single elastic medium, the action of the material molecules not being considered, as in the theories of Fresnel, Cauchy, Neumann, Maccullagh, and Green, or whether the phenomena of crystalline refraction and reflection are due to a direct action between the material molecules and the etherial medium.

It becomes necessary, therefore, to consider, at the outset, the physical facts which throw light on this question.

It was shown by Sir David Brewster, in 1818, that crystals belonging to the prismatic, oblique, and anorthic systems are biaxal, those belonging to the pyramidal and rhombohedral systems uniaxal, while crystals of the cubic system do not possess double refraction (a fact which had been previously stated by Hauy.)

Hence, when the material molecules are symmetrically

arranged, with respect to three planes at right angles to each other (as in the prismatic), or where there is only one plane of symmetry (as in the oblique), or none, as in the anorthic system, there are two optic axes. When the material molecules are symmetrically arranged about one straight line as an axis, there is only one optic axis, which coincides with the axis of symmetry of the crystal; but if they are symmetrical about three lines at right angles to each other, there is no double refraction; in other words, every straight line in the crystal becomes an optic axis.

The optical properties of crystals, therefore, are connected with the arrangement in space of the material molecules of which they are built up. When the latter varies, the former vary also.

Again, in quartz and dextro- and lævo-tartaric acids (as observed by Pasteur), the rotation of the plane of polarisation is to the right or the left, according as the hemihedral faces, which occur on crystals of these substances, are turned to the right or left. Here, then, a want of symmetry in the arrangement of the material molecules is coincident with a want of symmetry, so to speak, in optical properties.

But, in general, if the position of the molecules be changed in any manner, as by pressure, heat, or otherwise, the optical properties are also changed.

Thus, it has been shown by Sir David Brewster, that if to a crystal of the cubic system, or to a transparent substance like glass, we apply pressure in one direction, so that the mean distance of the material molecules in this direction becomes less than the distance in other directions, the substance becomes doubly-refracting. In reality, when pressure is applied in one direction, the crystal, as of fluor-spar for instance, can no longer be said to belong to the cubic system, but becomes changed into a crystal of the pyramidal system, the axes of which only differ by an extremely small amount, and the direction of the pressure is the direction of the principal, and therefore of the optic axis. In this way glass, jelly, crystals of common salt, &c., can be rendered doubly refracting. This is also the case if the mean distance of the molecules be *increased* in some directions,

and not in others, as when a piece of glass is rendered doubly-refracting by bending, the inner strata on the concave side of the bend being compressed, and those on the outside dilated.

The optical properties of doubly-refracting crystals are also changed by pressure, as was also shown by Sir David Brewster, and also by the action of heat. Now crystals, except those of the cubic system, are, in general, dilated differently in different directions by the action of heat. Thus, in a rhombohedron of calcite increase of temperature alters the angles between the faces, making them approach more nearly to a cube; and, at the same time, the extraordinary refractive index is increased. A similar property has been recently observed by Fizeau in quartz, who finds that the extraordinary refractive index is diminished by rise of temperature, the rhombohedron in this case departing further from the form of a cube. In gypsum, to take the case of a biaxal crystal, Mitscherlich found that change of temperature alters in a remarkable manner the angle between the optic axes. More recently, Des Cloizeaux has shown that this is the case in a number of minerals, such as brookite, chrysoberyl, and certain species of felspar. In general, when the heat is removed, and the crystal regains its original temperature, the angle between the optic axes becomes the same as before, the molecules having then regained their original positions. Des Cloizeaux also found that, in certain minerals, the angle between the optic axes became permanently changed by exposing them to a high temperature. In these cases we may suppose a permanent change to have taken place in the position of the molecules, as when a solid is distorted beyond the limits of elasticity, or the limits within which Hooke's law holds, in which case a permanent change in the position of the molecules takes place.

In the above and similar cases, therefore, a change in the position of the material molecules produced by heat, causes a change in optical properties.

It is well known that we may render a cylinder of glass transiently doubly refracting by immersing it in heated oil, a circular cylinder giving the same rings as a uniaxal, and

an elliptic cylinder the same as a biaxal crystal, these phenomena ceasing as soon as the glass becomes uniformly heated. If a cylinder of glass, which has been heated to redness, be rapidly cooled at the exterior, the glass becomes permanently doubly-refracting, the position of the molecules being in this case permanently altered.

These, and the phenomena produced in crystals by the *combined* effects of heat and pressure, may all be accounted for by the different changes in different directions, which take place in the position of the material molecules by the action of these causes.

The next question is, whether the optical properties of crystals are determinated solely by the mass of the molecules and their arrangement in space, or are they dependent on the *nature* of the molecule, that is, on its chemical constitution, or the kind of matter of which it is built up?

The principal facts bearing on this point, which at first sight appear to show that such is the case, were observed by De Senarmont, who found that a change in the composition of the molecule, produced by isomorphous replacement, alters the angle between the optic axes. But the change thus produced may, in reality, be due to the alteration in the arrangement, and to the change of mass of the molecules, consequent on isomorphous replacement. It may be objected, that such a supposition is contrary to the very meaning of isomorphism, which asserts that isomorphous substances can replace each other in all proportions, without any alteration in the form of the crystal, that is, in the arrangement of the molecules. It has, however, never been established, that the angles between the faces of crystals remain unaltered by isomorphous replacement; on the contrary, it appears to be very probable that this is not the case, from the very fact that isomorphous substances differ, in some cases considerably, in their "angular elements," as determined by the angles between the faces of crystals. In reality, there is no such thing as absolute isomorphism. In the well-known case, for instance, of the isomorphism of the carbonates of calcium, lead, strontium, and barium, in the minerals aragonite, cerussite, strontianite, and witherite,

the angular elements differ from 30′ to 2°, so that when these substances replace one another isomorphously, it is quite reasonable to suppose that changes, although no doubt slight ones, are produced in the crystalline form. This may be illustrated by the mineral alstonite, which may be looked upon as aragonite, in which half the carbonate of calcium is replaced by carbonate of barium, the angular elements of aragonite being thereby altered from 58° 5′ and 40° 50′ to 59° 25′·5 and 38° 39′, differing respectively by 1° 20′·5 and 2° 11′ from those of aragonite. We may say that the angular elements of aragonite have been altered to this amount by isomorphous replacement.

It will be seen that the view we take is, that chemical composition has no *direct* effect upon optical properties, but that it influences them only inasmuch as the form of a crystal is determined by its chemical composition, and the optical properties are held to be *directly* due to the form of the crystal, or to the arrangement of the molecules. It may be argued, that the form of a crystal is not entirely determined by its molecular constitution, as shown by the facts of dimorphism. We hold, however, that all the so-called cases of dimorphism can be explained by real, though small, differences in chemical constitution, and differences in temperature and pressure at which the crystals were formed, and that a substance of given chemical composition, when crystallised under the same physical conditions as to pressure and temperature, will always assume the same form.

Take the case of titanic acid, which is said to be trimorphous in anatase, rutile, and brookite. In these minerals the titanic acid is always associated with variable quantities of sesquioxide of iron. Or consider again the dimorphism of carbonate of calcium, as calcite and aragonite. Aragonite is never pure carbonate of calcium, but is always associated with variable quantities of the carbonates of lead, strontium, and manganese. Calcite contains substances like carbonate of iron, oxide of zinc, &c. In other cases of dimorphism, as of sulphur, and the artificial production of calcite and aragonite from pure carbonate of calcium, the physical con-

ditions differ under which the crystals are formed. In conclusion, there appears to be no established exception to the law, that the arrangement of the material molecules in space is definite for a substance of definite composition, and that, therefore, any change in chemical composition must be attended by a change in the arrangement of the molecules, and also in their mass, and hence by a change in optical properties.

It may be objected that the variations in the angle between the optic axes, observed by De Senarmont, are too large to be accounted for by the small changes in the arrangement of the molecules, which could be produced by isomorphous replacement; but, *a priori*, there is nothing to show that very small changes in position of the molecules, especially if the forces exercised by the molecules on the etherial medium are sensible only at insensible distances, as without doubt they are, may not produce a change in the magnitude and direction of the resultant action on the elements of the ethereal medium, by no means insensible in its effect on the indefinitely small vibrations of the ether. That a minute change in the position of the molecules does produce a change in optical properties, is shown by the effect of pressure in producing double refraction in jelly, fluor-spar, &c.

But if the optical properties of crystals are really caused by an action between the material molecules and the etherial medium, then the special optical properties of a given crystal should depend on the special arrangement of the molecules in that crystal, as shown by the form of the crystal, and expressed crystallographically by the system to which it belongs, and by the angles between its faces, that is, by the magnitude of its angular elements. In other words, some connection ought to exist between the form and optical properties of crystals; and it ought to be possible to express the latter in terms of the angular elements of the crystal, and certain other constants dependent on the constitution of the ether, &c. That such a connection does exist, few physicists would, I think, be found to deny. De Senarmont, however, drew from his experiments on the variation of the

angle between the optic axes produced by isomorphous replacement, conclusions which led him to deny the existence of such a connection. His words are:* "Les expériences détaillées dans ce Memoire tendent à cette conclusion, que les causes mécaniques déterminantes de la forme géometrique sont d'un autre ordre que les causes mécaniques déterminantes des propriétés optiques biréfringentes, puisque cette forme demeure la même dans des groupes entiers de substances isomorphes, tandis que les propriétés optiques éprouvent, dans leurs éléments essentiels, non-seulement des modifications de quantité, mais une inversion complète dé grandeur relative. *Une même cause ne saurait se manifester en même temps par des effets géométriques semblables et par des effets optiques opposés.*"

In reply to De Senarmont, it is only necessary to remark, that the crystalline form does not "demeure la même dans des groupes entiers de substances isomorphes," nor are the "effets géométriques *semblables.*" As before observed, no two isomorphous substances have exactly the same crystalline form; and their angular elements, even in the most well-known groups, sometimes differ as much as 2° 30′. This variation in form is amply sufficient to account for the variation in the angle between the optic axes of so-called isomorphous substances. De Senarmont here has been plainly misled by the derivation of the word, forgetting that the only sense in which substances are said to be isomorphous is in being able to replace each other in all proportions without *essentially* altering the crystalline form. As an experimental fact, substances capable of replacing each other in this manner are found to possess *approximately* the same crystalline form.

Impressed by the facts now adduced of the dependence of the optical properties of a crystal on its form, that is, on the arrangement of the material molecules therein, I have for a long time attempted to discover formulæ expressing directly some of the optical properties in terms of the angles between the faces or the angular elements. Having seen how essen-

* Annales de Chimie 1851, vol. xxxiii. page 433.

tially connected the possibility of discovering such a formula must be with the state of our knowledge of the laws of symmetry of crystalline forms, I was led into some rather extended researches on this latter subject, the result of which was to induce me to take a different view of the laws of symmetry of those uniaxal crystals which belong to the rhombohedral system from those previously held by crystallographers. Having discovered that such crystals were in reality subject to the same laws of symmetry as crystals of the prismatic system,—one of the angular elements being always equal to 60°,—I was led almost immediately afterwards to a formula, expressing the angle between the optic axes of a crystal of the prismatic system in terms of the angular elements,* which agrees remarkably with observation for those crystals for which both the angle between the optic axes and the angular elements have been most accurately determined. In the case of aragonite, the angle between the optic axes, as calculated by the formula from its angular elements, differs from Kirchhoff's very accurate measurements† for mean rays by only 15′, in the case of chrysoberyl by 19′. In the case of other minerals, as karstenite (anhydrite), nitre, cerussite, the calculated agrees with the observed angle, by making slight changes in the generally received values of the angular elements, which are quite within the limits of errors of observation, or of the variations in the angular elements observed in different specimens of the same mineral.

I am at present engaged on further investigations connected with this formula; but in the meantime, although perhaps it may require some modification, I am impressed with the conviction that it contains the elements of truth. Such a formula would, of course, be a most important guide in all theoretical researches in which the action of the material molecules is attempted to be taken into account.

It is needless here to dilate upon the admitted defects of

* "On the Connection between the Form and Optical Properties of Crystals," Proceedings Royal Society, Edinburgh, 2d May 1864.

† Kirchhoff, Pogg. Annalen, cviii. (1859) p. 574.

the theories of Fresnel, Cauchy, Neumann, &c., in which the motion of the ether within a crystal is determined as if it were a single vibrating medium unacted on by the molecules which interpenetrate it, and possessing special properties different from what it is supposed to possess *in vacuo*, without at the same time attempting to give any explanation of the manner in which the ether might be supposed to have derived these properties. These theories, even with the arbitrary hypotheses made, are unsatisfactory in other respects.

The idea that the action of the material molecules must be taken into account, in any satisfactory theory of crystalline refraction, appears to have suggested itself many years ago to several physicists. Even Cauchy latterly felt the necessity of doing so, as appears from some investigations in one of the volumes of the "Nouveaux Exercices," and from his papers in the twenty-second volume of the "Memoires de l'Institut." Lamé has also made investigations in this direction (see a memoir in the "Journal de l'Ecole Polytechnique," tom. xiv.) Dr Lloyd, in the first number of the "Proceedings of the Royal Irish Academy," describes in words some researches he had made with the same object; and, finally, Professor Stokes, in his "Report on Double Refraction" to the Cambridge meeting of the British Association in 1862, in expressing his "belief that the true dynamical theory of double refraction has yet to be found," indicates his opinion very decidedly, that "the ponderable molecules must be taken into account in a far more direct manner" than has been done in previous theories.

We now proceed to investigate the general equations of motion of the etherial medium, when acted upon by the material molecules, supposing the ether to be *discontinuous*, and to be incompressible by the forces exerted upon it by the material molecules.*

Let $x\ y\ z$, $x_1\ y_1\ z_1$, be the co-ordinates of particles of

* It is desirable to investigate the consequences of this supposition in the first place, on account of the simplification which is thereby introduced into the equations of motion.

ether when in equilibrium; $u\ v\ w$, $u_1\ v_1\ w_1$, their displacements parallel to the co-ordinate axes at time t when in motion.

Let $x'\ y'\ z'$ be the co-ordinates of a particle of matter when in equilibrium; $u'\ v'\ w'$ its displacements parallel to the axes at time t when in motion.

Let $\pi_x\ \pi_y\ \pi_z$ represent the resolved parts parallel to the axes of the resultant action of the material molecules on the particle of ether at $x\ y\ z$.

Let $\varphi_x\ \varphi_y\ \varphi_z$ be the resolved parts parallel to the axes of the action of the etherial medium on the particle of ether at $x\ y\ z$.

Then, when the ether is in equilibrium,

$$\pi_x + \varphi_x = 0 \qquad \pi_y + \varphi_y = 0 \qquad \pi_z + \varphi_z = 0$$

Suppose now the ether and the material molecules to be set in motion, so that the motion of both is indefinitely small; then the particle of ether which was originally at $x\ y\ z$ is at time t at the point $x + u$, $y + v$, $z + w$.

We have now, therefore, to express the resultant actions on this particle in the position which it occupies at time t. In consequence of the motion of the material molecules let π_x at $x\ y\ z$ become $\pi_x + \delta\pi_x$. Let π_x' denote the resultant action parallel to the axis of x, which the material molecules in their position of equilibrium exert at $x + u$, $y + v$, $z + w$.

Then, since π_x depends only on $x\ y\ z$,

$$\pi_x' = \pi_x + \frac{d\pi_x}{dx}u + \frac{d\pi_x}{dy}v + \frac{d\pi_x}{dz}w \quad . \ . \ . \ . \ . \ (1)$$

neglecting terms of the second order in $u\ v\ w$. Hence the resultant action on the particle of ether at $x + u$, $y + v$, $z + w$, when the material molecules are in motion

$$= \pi_x + \delta\pi_x + \frac{d(\pi_x + \delta\pi_x)}{dx}u + \frac{d(\pi_x + \delta\pi_x)}{dy}v + \frac{d(\pi_x + \delta\pi_x)}{dz}w$$

substituting $\pi_x + \delta\pi_x$ for π_x in (1.)

Now

$$\frac{d(\delta\pi_x)}{dx}u + \frac{d(\delta\pi_x)}{dy}v + \frac{d(\delta\pi_z)}{dz}w =$$

$$\delta\left(\frac{d\pi_x}{dx}\right)u + \delta\left(\frac{d\pi_x}{dy}\right)v + \delta\left(\frac{d\pi_x}{dz}\right)w$$

and therefore the expression on the left hand side is of the second order in u v w, and may therefore be neglected.

Hence the resultant action at $x + u$, $y + v$, $z + w$, parallel to the axis of x, due to the material molecules in motion,

$$= \pi_x + \frac{d\pi_x}{dx}u + \frac{d\pi_x}{dy}v + \frac{d\pi_x}{dz}w + \delta\pi_x \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and

$$\delta\pi_x = \Sigma\left\{\frac{d\pi_x}{dx'}u' + \frac{d\pi_x}{dy'}v' + \frac{d\pi_x}{dz'}w'\right\} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Similar expressions may be found for the resultant actions parallel to the axes of y and z.

The action on the particle of ether at $x + u$, $y + v$, $z + w$, parallel to the axis of x, due to the etherial medium when in motion, may, by analogy from (2.), be expressed in the form

$$\varphi_x + \frac{d\varphi_x}{dx}u + \frac{d\varphi_x}{dy}v + \frac{d\varphi_x}{dz}w + \delta\varphi_x \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and

$$\delta\varphi_x = \Sigma\left\{\frac{d\varphi_x}{dx_1}u_1 + \frac{d\varphi_x}{dy_1}v_1 + \frac{d\varphi_x}{dz_1}w_1\right\} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Hence, adding (2.) and (4.), and recollecting that $\pi_x + \varphi_x = 0$, we have for the motion of the ether the equations

$$\frac{d^2u}{dt^2} = \frac{d\varphi_x}{dx}u + \frac{d\varphi_x}{dy}v + \frac{d\varphi_x}{dz}w + \delta\varphi_x$$

$$+ \frac{d\pi_x}{dx}u + \frac{d\pi_x}{dy}v + \frac{d\pi_x}{dz}w + \delta\pi_x \quad . \quad . \quad . \quad (6)$$

$\frac{d^2v}{dt^2}$ = similar expression, involving π_y and φ_y

$\frac{d^2w}{dt^2}$ = similar expression, involving π_z and φ_z

where $\delta\pi_x$, $\delta\varphi_x$, &c., are given by (3.), (5.), and similar expressions.

Let m be the mass of one of the particles of ether. Then, if $r\psi r$ be the law of action of the etherial particles upon each other

$$\varphi_x = m\,\Sigma\{\psi r_1(x_1 - x)\}$$

or putting

$$x_1 - x = h_1$$

$$\varphi_x = m\,\Sigma\{\psi r_1\ h_1\}$$

$$\therefore\quad \frac{d\varphi_x}{dx_1} = -\frac{d\varphi_x}{dx} = m\,\Sigma\left\{\frac{1}{r_1}\,\psi' r_1\ h_1^2 + \psi r_1\right\}$$

For shortness put $\varphi r_1 = \frac{1}{r_1}\psi' r_1$

$$\therefore\quad \frac{d\varphi_x}{dx_1} = m\,\Sigma\left\{\varphi r_1\ h_1^2 + \psi r_1\right\} \quad . \quad . \quad . \quad . \quad (7)$$

Similarly

$$\frac{d\varphi_x}{dy_1} = -\frac{d\varphi_x}{dy} = m\,\Sigma\left\{\varphi r_1\ h_1 k_1\right\} \quad . \quad . \quad (8)$$

$$\frac{d\varphi_x}{dz_1} = -\frac{d\varphi_x}{dz} = m\,\Sigma\left\{\varphi r_1\ h_1 l_1\right\} \quad . \quad . \quad (9)$$

Now

$$\delta\varphi_x = \Sigma\left\{\frac{d\varphi_x}{dx_1}u_1 + \frac{d\varphi_x}{dy_1}v_1 + \frac{d\varphi_x}{dz_1}w_1\right\}$$

And

$$u_1 = u + h_1\frac{du}{dx} + k_1\frac{du}{dy} + l_1\frac{du}{dz}$$
$$+ \frac{1}{2}\left\{h_1^2\frac{d^2u}{dx^2} + k_1^2\frac{d^2u}{dy^2} + l_1^2\frac{d^2u}{dz^2}\right.$$
$$\left. + 2h_1k_1\frac{d^2u}{dxdy} + 2h_1l_1\frac{d^2u}{dxdz} + 2k_1l_1\frac{d^2u}{dydz}\right\} + \&c. \quad (10)$$

In finding the value of $\Sigma\left\{\frac{d\varphi_x}{dx_1}u_1\right\}$ let us suppose the sphere of action of the molecular forces to be so small that ψr_1 becomes insensible when multiplied by factors higher than the *third* in $h_1\ k_1\ l_1$. Then since $h_1\ k_1\ l_1$ are of the

same order as r_1, and since $\phi r_1 \; h_1^2$ is two dimensions in r_1 lower than ψr_1, we must retain terms of the form $\Sigma\{\phi r_1 \; h_1^m\}$, &c., to the *fifth* order in $h_1 \; k_1 \; l_1$.

Also, since the particles of ether are symmetrically arranged, if fr be any function of r, $m\,\Sigma\{fr\; h^p\, k^q\, l^r\}$ vanishes, unless $p\; q\; r$ are all even, and then its value is the same in whatever manner $p\; q\; r$ be interchanged. Hence from (7) and (10) we find

$$\Sigma \frac{d\phi_x}{dx_1} u_1 = \Sigma \left\{ \phi r_1 \; h_1^2 + \psi r_1 \right\} u$$

$$+ \left\{ \frac{1}{2} \Sigma\phi r_1 \; h_1^4 \quad + \frac{1}{2} \Sigma\psi r_1 \; h_1^2 \right\} \frac{d^2u}{dx^2}$$

$$+ \left\{ \frac{1}{2} \Sigma\phi r_1 \; h_1^2 k_1^2 + \frac{1}{2} \Sigma\psi r_1 \; k_1^2 \right\} \frac{d^2u}{dy^2}$$

$$+ \left\{ \frac{1}{2} \Sigma\phi r_1 \; h_1^2 l_1^2 + \frac{1}{2} \Sigma\psi r_1 \; l_1^2 \right\} \frac{d^2u}{dz^2} \quad . \; . \quad (11)$$

Put $$\mathrm{R} = \frac{1}{6} \Sigma \left\{ \phi r_1 \; h_1^4 \right\}$$

Then it can be easily shown that

$$\frac{1}{2} \Sigma \left\{ \phi r_1 \; h_1^2 k_1^2 \right\} = \frac{1}{2} \Sigma \left\{ \phi r_1 \; h_1^2 l_1^2 \right\} = \frac{1}{2} \Sigma \left\{ \phi r_1 \; k_1^2 l_1^2 \right\} = \mathrm{R}.$$

And let $$\frac{1}{2} \Sigma \, \psi r_1 \; h_1^2 = \text{\&c.} \quad . \; . \; . \; . \; . \; . \quad = \mathrm{S}.$$

Then equation (11) becomes

$$\Sigma \frac{d\phi_x}{dx_1} u_1 + \frac{d\phi_x}{dx} u$$

$$= \left(3\mathrm{R} + \mathrm{S}\right) \frac{d^2u}{dx^2} + \left(\mathrm{R} + \mathrm{S}\right) \frac{d^2u}{dy^2} + \left(\mathrm{R} + \mathrm{S}\right) \frac{d^2u}{dz^2} \quad (12)$$

Similarly it may be shown that

$$\Sigma \frac{d\phi_x}{dy_1} v_1 = \Sigma \left(\phi r_1 \; h_1^2 k_1^2 \right) \frac{d^2v}{dxdy} = 2\mathrm{R} \frac{d^2v}{dxdy} \quad . \; . \, (13)$$

And $$\Sigma \frac{d\phi_x}{dz_1} w_1 = \Sigma \left(\phi r_1 \; h_1^2 l_1^2 \right) \frac{d^2w}{dxdz} = 2\mathrm{R} \frac{d^2w}{dxdz} \quad . \; . \, (14)$$

Also by (8) and (9)

$$\frac{d\phi_x}{dy} = \frac{d\phi_x}{dz} = 0 \quad . \; . \; . \; . \; . \; . \; . \quad (15)$$

by the symmetry of the arrangement of the etheria particles.

Hence from (12), (13), (14), and (15)

$$\frac{d\varphi_x}{dx}u + \frac{d\varphi_x}{dy}v + \frac{d\varphi_x}{dz}w + \delta\varphi_x$$

$$= \left(3\mathrm{R} + \mathrm{S}\right)\frac{d^2u}{dx^2} + \left(\mathrm{R} + \mathrm{S}\right)\frac{d^2u}{dy^2} + \left(\mathrm{R} + \mathrm{S}\right)\frac{d^2u}{dz^2}$$

$$+ 2\mathrm{R}\frac{d}{dx}\left(\frac{dv}{dy} + \frac{dw}{dz}\right)$$

Now, if the vibrations of the ether be transversal to the direction of propagation,

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0.$$

Hence in this case

$$\left(3\mathrm{R} + \mathrm{S}\right)\frac{d^2u}{dx^2} + 2\mathrm{R}\frac{d}{dx}\left(\frac{dv}{dy} + \frac{dw}{dz}\right) = \left(\mathrm{R} + \mathrm{S}\right)\frac{d^2u}{dx^2}$$

Hence putting $\mathrm{R} + \mathrm{S} = \mathrm{A}$ we have

$$\frac{d\varphi_x}{dx}u + \frac{d\varphi_x}{dy}v + \frac{d\varphi_x}{dz}w + \delta\varphi^x$$

$$= \mathrm{A}\left\{\frac{d^2u}{dx^2} + \frac{d^2u}{dy^2} + \frac{d^2u}{dz^2}\right\} \quad . \quad . \quad . \quad . \quad (16)$$

Again, if m' be the mass of one of the material molecules, and $r'fr'$ the law of the action of the molecules on the ether,

$$\pi_x = m'\Sigma\{fr'(x' - x)\}$$

$$= m'\Sigma fr' \, . \, h' \quad \text{say}$$

$$\therefore \frac{d\pi_x}{dx} = -m'\Sigma\left\{\frac{1}{r'}f'r'\,h'^2 + fr'\right\} \quad . \quad . \quad . \quad (17)$$

$$\frac{d\pi_x}{dy} = -m'\Sigma\left\{\frac{1}{r'}f'r'\,h'\,k'\right\} \quad . \quad . \quad . \quad . \quad (18)$$

$$\frac{d\pi_x}{dz} = -m'\Sigma\left\{\frac{1}{r'}f'r'\,h'\,l'\right\} \quad . \quad . \quad . \quad . \quad (18^*)$$

Now, let us take as the typical case of a biaxal crystal

one belonging to the prismatic system. Biaxal crystals belonging to the oblique and anorthic systems may, for the purposes of this investigation, be considered as formed by the combination of hemihedral and tetrahedral forms of the prismatic system.

In the prismatic system the molecules are symmetrically arranged with respect to three planes at right angles to each other. Also, if a very small crystal be taken out of a larger crystal by cleavage or otherwise, it is also biaxal, and possesses optical properties similar to those of the larger crystal, the optic axes being in the same direction, &c. The larger crystal may therefore be considered to be built up of an indefinite number of very small crystals of the prismatic system, and each of these small crystals may be supposed to contain all the material molecules which are capable of influencing the motion of the ether within them. Hence at every point of a crystal we may suppose that the molecules which can affect the motion of the ether at that point are symmetrically arranged with respect to three planes at right angles to each other, and parallel to the principal planes of the crystal.

Hence

$$\Sigma \left\{ \frac{1}{r'} f' r' \, h' \, k' \right\} = 0, \text{ \&c.}$$

$$\therefore \quad \frac{d\pi_x}{dy} = 0 \qquad \frac{d\pi_x}{dz} = 0, \text{ by (18) and (18*).}$$

And $$\frac{d\pi_x}{dx} = - m' \Sigma \left\{ \frac{1}{r'} f' \, r' \, h'^2 + f r' \right\} = - \text{P, say}$$

$$\therefore \quad \frac{d\pi_x}{dx} u + \frac{d\pi_x}{dy} v + \frac{d\pi_x}{dz} w = - \text{P} u, \quad . \quad . \quad . \quad (19)$$

Also $$\delta\pi_x = \Sigma \left\{ \frac{d\pi_x}{dx'} u' + \frac{d\pi_x}{dy'} v' + \frac{d\pi_x}{dz'} w' \right\}$$

Hence by analogy, from the value of $\delta\varphi_x$, we may put

$$\delta\pi_x = \text{P}u' + \text{A}' \frac{d^2 u'}{dx'^2} + \text{B}' \frac{d^2 u'}{dy'^2} + \text{C}' \frac{d^2 u'}{dz'^2} \quad . \quad . \quad (20)$$

where A′ B′ C′ are constants depending on the arrangement of the material molecules, that is, on the crystalline

parameters or angular elements. For a crystal of the prismatic system A′ B′ C′ are all unequal; for a crystal of the pyramidal system two of them will become equal. In a crystal of the cubic system A′ B′ C′ will be all equal.

Hence, substituting from (16), (19), and (20), in equations (6), the general equations of motion of the ether become

$$\frac{d^2u}{dt^2} = \mathrm{A}\left\{\frac{d^2u}{dx^2} + \frac{d^2u}{dy^2} + \frac{d^2u}{dz^2}\right\} - \mathrm{P}u + \mathrm{P}u'$$
$$+ \mathrm{A}'\frac{d^2u'}{dx'^2} + \mathrm{B}'\frac{d^2u'}{dy'^2} + \mathrm{C}'\frac{d^2u'}{dz'^2}$$

$$\frac{d^2v}{dt^2} = \mathrm{A}\left\{\frac{d^2v}{dx^2} + \frac{d^2v}{dy^2} + \frac{d^2v}{dz^2}\right\} - \mathrm{P}v + \mathrm{P}v'$$
$$+ \mathrm{A}'\frac{d^2v'}{dx'^2} + \mathrm{B}'\frac{d^2v'}{dy'^2} + \mathrm{C}'\frac{d^2v'}{dz'^2}$$

$$\frac{d^2w}{dt^2} = \mathrm{A}\left\{\frac{d^2w}{dx^2} + \frac{d^2w}{dy^2} + \frac{d^2w}{dz^2}\right\} - \mathrm{P}w + \mathrm{P}w'$$
$$+ \mathrm{A}'\frac{d^2w'}{dx'^2} + \mathrm{B}'\frac{d^2w'}{dy'^2} + \mathrm{C}'\frac{d^2w'}{dz'^2}. \quad . \quad . \quad (21)$$

The coefficients of v' w', in the second and third equations, have in reality different values from the coefficient of u' in the first equation. But, as will afterwards be seen, in the integration of the equations, these terms give rise to others involving the square of the wave-length, and are therefore only important in the explanation of the dispersion of light. Hence we may, without sensible error, suppose the coefficients of v' and w' to have the same value as the coefficient of u'.

We must now find the equations of motion of the material molecules. Now, whatever be the nature of the molecular forces of cohesion, &c., all such forces are here supposed, in accordance with the tendency of modern science, to have their origin either in the action which matter exerts upon matter, or in the action which the etherial medium exerts upon matter. We shall therefore suppose the material molecules to be retained in their positions of equilibrium by the forces exerted upon them by the other material

molecules of the solid, and by the forces exerted upon them by the etherial medium.

On this supposition, the equations of motion of the material molecules may be immediately written down by analogy from the equations of motion of the ether.

For if we substitute *matter* for *ether*, and *ether* for *matter*, the above investigation of the equations of motion of the ether applies also to this case, and we are thus enabled to write down at once the equations of motion of the material molecules.

They are, therefore,

$$\frac{d^2u'}{dt^2} = F'\frac{d^2u'}{dx'^2} + G'\frac{d^2u'}{dy'^2} + H'\frac{d^2u'}{dz'^2} - P'u' + P'u + F\left\{\frac{d^2u}{dx^2} + \frac{d^2u}{dy^2} + \frac{d^2u}{dz^2}\right\}$$

$$\frac{d^2v'}{dt^2} = F'\frac{d^2v'}{dx'^2} + G'\frac{d^2v'}{dy'^2} + H'\frac{d^2v'}{dz'^2} - P'v' + P'v + F\left\{\frac{d^2v}{dx^2} + \frac{d^2v}{dy^2} + \frac{d^2v}{dz^2}\right\}$$

$$\frac{d^2w'}{dt^2} = F'\frac{d^2w'}{dx'^2} + G'\frac{d^2w'}{dy'^2} + H'\frac{d^2w'}{dz'^2} + P'w' + P'w + F\left\{\frac{d^2w}{dx^2} + \frac{d^2w}{dy^2} + \frac{d^2w}{dz^2}\right\} \quad . \quad . \quad . \quad . \quad (22)$$

All the constants in these equations must in general be supposed different from the constants in equations (21). In order to investigate the motion of plane waves, let us put

$$\left.\begin{aligned} \frac{u}{\alpha} &= \frac{v}{\beta} = \frac{w}{\gamma} = \sin\frac{2\pi}{\lambda}\{lx + my + nz - vt\} \\ \frac{u'}{\alpha'} &= \frac{v'}{\beta'} = \frac{w'}{\gamma'} = \sin\frac{2\pi}{\lambda'}\{l'x' + m'y' + n'z' - v't\} \end{aligned}\right\} \quad (23)$$

On making these substitutions each of the equations (21) gives the same equation of condition, in order that the above values of $u\ v\ w,\ u'\ v'\ w'$ may satisfy them.

Each of the equations (22) also gives the same equation of condition.

Differentiating equations (23) we get

$$\frac{d^2u}{dt^2} = -\frac{4\pi^2}{\lambda^2} v^2\alpha \sin\frac{2\pi}{\lambda}(lx + my + nz - vt)$$

$$= -\frac{4\pi^2}{\lambda^2} v^2 u$$

$$\frac{d^2u}{dx^2} = -\frac{4\pi^2}{\lambda^2} l^2 u$$

&c. &c.

$$\frac{d^2u'}{dt^2} = -\frac{4\pi^2}{\lambda'^2} v'^2 u'$$

$$\frac{d^2u'}{dx'^2} = -\frac{4\pi^2}{\lambda'^2} l'^2 u'$$

&c. &c.

Hence substituting in any of the equations (21) we have

$$v^2 u = A(l^2 + m^2 + n^2) + P\frac{\lambda^2}{4\pi^2} u - P\frac{\lambda^2}{4\pi^2} u'$$

$$+ \frac{\lambda^2}{\lambda'^2}\left(A'l'^2 + B'm'^2 + C'n'^2\right) u'$$

$$\therefore \left(v^2 - A - P\frac{\lambda^2}{4\pi^2}\right) u$$

$$= \left\{ \frac{\lambda^2}{\lambda'^2}(A'l'^2 + B'm'^2 + C'n'^2) - P\frac{\lambda^2}{4\pi^2} \right\} u' \quad . \; . \; (24)$$

Similarly from equations (22)

$$\left\{ v'^2 - (F'l'^2 + G'm'^2 + H'n'^2) - P'\frac{\lambda'^2}{4\pi^2} \right\} u'$$

$$= \left\{ \frac{\lambda'^2}{\lambda^2} F - P'\frac{\lambda'^2}{4\pi^2} \right\} u \quad . \; . \; . \; . \; (25)$$

Multiply the right and left hand sides respectively of (24) and (25), and divide by uu', and we have

$$\left(v^2 - A - P\frac{\lambda^2}{4\pi^2}\right) \left\{ v'^2 - (F'l'^2 + G'm'^2 + H'n'^2) - P'\frac{\lambda'^2}{4\pi^2} \right\}$$

$$= \left(F - P'\frac{\lambda^2}{4\pi^2}\right) \left\{ A'l'^2 + B'm'^2 + C'n'^2 - P\frac{\lambda'^2}{4\pi^2} \right\} \; (26)$$

Let us neglect the terms containing λ^2 and λ'^2, which are

necessarily very small compared with the other terms, and are only important when considering the dispersion of light. Then the equation (26) becomes

$$(v^2 - A)\ \{v'^2 - (F'l'^2 + G'm'^2 + H'n'^2)\}$$
$$= F(A'l'^2 + B'm'^2 + C'n'^2)$$

Now, if we suppose that the velocity of propagation of the wave through the material molecules is such that $v'^2 = k^2v^2$, the above becomes a quadratic in v^2, viz. :—

$$k^2v^4 - \{Ak^2 + F'l'^2 + G'm'^2 + H'n'^2\}\,v^2$$
$$+ A(F'l'^2 + G'm'^2 + H'n'^2)$$
$$- F(A'l'^2 + B'm'^2 + C'n'^2) = 0 \quad . \quad . \quad . \quad (27)$$

Hence, in this case, there are two values of v^2 for given values of $l'm'n'$. Hence, in general, there would be two refracted rays for a given incident ray, and thus we have a general explanation of the double refraction of light.

Also, since the vibrations are transversal,

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0\,.$$

$$\therefore\ l\alpha + m\beta + n\gamma = 0$$

or

$$lu + mv + nw = 0$$

Now from equation (24)

$$\frac{u}{u'} = \frac{v}{v'} = \frac{w}{w'} = \frac{\lambda^2}{\lambda'^2}\left(\frac{A'l'^2 + B'm'^2 + C'n'^2}{v^2 - A}\right) \quad . \quad . \quad (28)$$

$$= \frac{lu + mv + nw}{lu' + mv' + nw'}$$

But

$$lu + mv + nw = 0$$
$$\therefore\ lu' + mv' + nw' = 0$$

Therefore the vibrations of the material molecules are also transversal and parallel to the plane

$$lx + my + nz = 0$$
$$\therefore\ l' = l \qquad m' = m \qquad n' = n$$

Let $v_1{}^2$ and $v_2{}^2$ be the roots of the equation (27), and let

u_1u_1', u_2u_2', v_1v_1', $v_2^2v_2'$, &c., be the corresponding values of uu', vv', &c.

Then, from (28)

$$\frac{u_1}{u_1'} = \frac{v_1}{v_1'} = \frac{w_1}{w_1'} = \frac{\frac{\lambda^2}{\lambda'^2} A'l^2 + B'm^2 + C'n^2}{v_1^2 - A} \tag{29}$$

$$\frac{u_2}{u_2'} = \frac{v_2}{v_2'} = \frac{w_2}{w_2'} = \frac{\frac{\lambda^2}{\lambda'^2} A'l^2 + B'm^2 + C'n^2}{v_2^2 - A} \tag{30}$$

$$\therefore \frac{u_1u_2}{u_1'u_2'} = \ldots\ldots = \frac{u_1u_2 + v_1v_2 + w_1w_2}{u_1'u_2' + v_1'v_2' + w_1'w_2'}.$$

Now, in order that the two rays may be polarised in planes at right angles to each other, we must have for all values of l, m, n,

$$u_1u_2 + v_1v_2 + w_1w_2 = 0$$

$$\therefore u_1'u_2' + v_1'v_2' + w_1'w_2' = 0.$$

Multiplying the expressions (29) and (30), and substituting for the values of v_1^2 and v_2^2 from (27), we easily find

$$\frac{u_1u_2 + \ldots\ldots}{u_1'u_2' + \ldots\ldots} = -\frac{k^2\lambda^4}{\lambda'^4}\;\frac{A'l^2 + B'm^2 + C'n^2}{Fl^2 + Gm^2 + Hn^2}$$

In order that this may become of the form $\frac{0}{0}$ for all values of l, m, n, we must have

$$A' = B' = C' = 0$$
$$F = G = H = 0$$

and then from (27)

$$v_1^2 = A$$
$$k^2v_2^2 = F'l^2 + G'm^2 + H'n^2$$

that is, one of the rays in every biaxal crystal follows the ordinary law of refraction, which is known not to be the case.

Hence the particular manner in which we have above attempted to take into account the action of the material molecules, although being remarkable as leading to a quadratic equation for the determination of the velocity of propagation of plane waves through crystallised media, fails when developed further.

Thus, on the above views, we cannot account for double refraction in a biaxal crystal if the ether be supposed incompressible by the action of the material molecules. If, however, the ether be supposed compressible, the equations of motion are of a more general character, the discussion of which will form the subject of a paper which the author hopes shortly to publish elsewhere.

IV.—(1.) *Notice of the* "ETUET," *a species of Tetraodon* (Tetraodon ——?) *recently received from the Rev. Alexander Robb, Old Calabar.* By JOHN ALEXANDER SMITH, M.D. (The specimen was exhibited.)

The following extract from a letter which I received from the Rev. Alexander Robb, dated Creektown, Old Calabar, 28th October 1864, gives all the information about this Tetraodon which I am able to lay before the Society:—

"The fish is named *Etuet* by the natives of Old Calabar, and possesses the power of inflating itself to an unusual degree. I do not know whether it has been described, but I think that it has been sent home. The *Etuet* is considered dangerous as food; but it is said that it can be eaten with safety by the removal of a certain part of it."

In March 1857, as noticed in the volume of our Proceedings for that year, Mr Andrew Murray exhibited a species of Tetraodon received from Old Calabar; and gives the following short account of its characters:—"It did not correspond with any of the species described by Lacepede, and was probably new. Instead of being armed with great spines, it was nearly smooth, except on the belly, where it was covered by a number of small prickles. It was dark brown above, and pale beneath, and had a row of six deep red spots along its sides. Mr Murray named it provisionally *Tetraodon pustulatus.*"

This may probably be the specimen to which the Rev. Mr Robb refers; and the description of its colour, and the spotted appearance of its sides, agree generally with the one now exhibited. This one seems to differ, however, from Mr Murray's specimen, in having apparently no spines

on the belly, but, instead, numerous small spines on the shoulder or back. The large teeth also, instead of projecting from the mouth, according to the character and name of the family *Gymnodontes*, in which its congeners have been placed, are apparently covered by its thick lips, so that the fish would appear, in this respect, to occupy a somewhat intermediate position between the *Sclerodermi* and the *Gymnodontes*. I shall therefore give a more detailed description of this specimen of *Tetraodon*.

It is a short and thick fish, with a rounded back; its greatest depth being a little behind the insertion of the pectoral fins, from which it tapers rapidly forward to its rather blunt snout or mouth; and from the same part of greatest depth, it tapers backwards more gradually towards the caudal fin. It measures rather more than 10 inches in length from the point of the snout, along the back, to the extremity of the tail, by 2½ inches in breadth at the base of the pectoral fins; and it is 3 inches in its greatest depth, a little behind the pectoral fins, where it measures 8 inches in circumference. The fish is of a brown colour above, apparently mottled with black (the specimen being preserved in spirits, the colours are uncertain), and is of a pale or white colour below the insertion of the pectoral fins; at the junction of these colours, along its sides, it is ornamented by a longitudinal series of bright scarlet spots, each more or less surrounded with black, which begins immediately behind the pectoral fin, and terminates at the root of the tail. In this fish there are six or seven of these spots on the one side, and seven or eight on the other.

The head measures 2½ inches in length from point of snout to branchial opening in front of pectoral fins, and about 1¾ inch in breadth behind the rather prominent red-coloured eyes, from which part it tapers rapidly forwards to its blunt or rounded snout; the thick lips of its somewhat crescentic-like mouth entirely cover and conceal the four large teeth, the upper pair of which project considerably over those of the lower jaw. The eyes are large and full, measuring nearly half an inch in greatest length in an oblique direction, and are placed at the distance of an inch

and a quarter from the point of the snout, and at about the same distance from one another, the forehead being rather rounded between them, and towards the point of the snout. About half an inch in front of the eyes, and about three-quarters of an inch from the front of the snout, there is on each side a pair of short cirri or tentacles, which project about an eighth of an inch, and are the prolongation of the olfactory organs.

The body measured along the back, and including the caudal fin, is about four times the length of the head. Its upper part, from the upper and back part of the head, to a little behind the pectoral fins, is thickly covered with very small, short, and fine bristle-like spines or prickles, which point backwards, making this part of the body feel rough to the finger, as it is drawn from behind forwards, while the rest of the body behind, and below, is smooth; on the under part of the throat and over the dilatable belly, there are numerous small pits or punctures in the fibrous-like structure of the elastic-looking skin, which suggest, at least, the possibility of having been filled with spines; no remains of spines, however, were found or felt in any of these little foramina, or any appearance of them discovered in the bottle in which the fish was preserved. These small spaces or pits left between the interlacing fibres of the skin may therefore be simply connected with the great dilatability of the skin of this part of the body.

The Fins are nearly equal in length; the *pectorals*, which appear as if cut square across at their extremities, being greatest in breadth, measuring an inch in length by one inch in breadth, and consist of eighteen rays. These fins are inserted about an inch and a quarter behind the eye, and immediately in front of their bases are the branchial openings, slightly curved backwards, and about half an inch in length. The *dorsal* fin is situated at $5\frac{3}{4}$ inches distance from the snout, measured along the back of the fish (the back part of the fin being $1\frac{3}{4}$ inch from the commencement of the caudal fin), it is $1\frac{1}{8}$th inch in length by $\frac{5}{8}$ths of an inch in breadth at the base, tapers slightly in shape, and

consists of eleven rays, the anterior rays being the longest. The *anal* fin, situated about half an inch behind the anus, and opposite to the dorsal, is rather smaller in size, 1 inch in length, by scarcely half an inch in breadth at the base, and consists of eight rays. The *caudal* fin is $2\frac{1}{4}$ inches in length, and $1\frac{1}{2}$ inch in breadth when expanded, and is very slightly rounded at its extremity. It appears to consist of eight large or double rays, each dividing into two rays.

A depressed fine line, faintly marked on the skin, surrounds each orbit in an irregularly rounded manner, at the distance of about half an inch from the orbit above, and of a quarter of an inch below; it sends off a short branch between the eye and pectoral fin, which runs downwards towards the belly. A very little behind this, and at the back part of the circle surrounding the orbit, on a line with the upper part of the pectoral fin, a distinct depressed line curves backwards and upwards; (after giving off a branch immediately in front of the fin which runs across the back part of the head to join the line of the opposite side), and runs backwards along the side of the fish to near the dorsal fin, where it next curves downwards a little way; and at about half an inch behind this fin, it sends off a short branch forwards towards the belly; and from this point of division it runs on to terminate at the centre of the base of the tail, forming thus the lateral line of the fish.

Whether this species may turn out to be the same as the one briefly described by Mr Murray, I do not at present know; although I rather regret he has fixed on the somewhat trivial name of *pustulatus*, as a series of spots along the side seems to be common to many species of this Genus; I shall therefore wait for more information before venturing to give this specimen any other specific designation.

Since this communication was read to the Society, I have had a reply from the Rev. Mr Robb, Old Calabar, to some of my inquiries about this fish. Mr Robb writes as follows:— "I may say that native information about animals is often very unreliable, though the best we can get. The Balloon or Globe Fish, the *Etuet* (ĕ-twét) is got in the river and

creeks by hooking, and by the nets which the natives use. It is not uncommon, but is considered unwholesome for food. The skin is taken off and dried, and used for making a small kind of drum. You notice its curious teeth. It has *no spines*. There are very small, very short, bristles about the side or shoulder; and a native told me that if these pierce the hand they cause injury, being poisonous, and that those who handle the fish remove the part where these small bristle points lie. I have examined the fish, and felt these same bristles, but have seen nothing dangerous about them; and other informants pronounced the fish quite harmless in respect of the little points. I have never seen a large one blown up, but have a very young one inflated, and will send it to you. The inflation is so great that the dead fish lies on its back. I believe the Etuet is found down near the river's mouth; it may be called an estuary fish. The etymology of the name I do not know. Most of our names being significant, I presume Etuet once was so; it would be a part of a verb descriptive of something about the fish. There is a kind of leech found in the marsh pools, which is called by the same name, probably because it becomes enlarged like the fish, when gorged with blood. The colour of the Etuet is lightish brown on the back, and white on the belly, with bright red spots running along both sides. There are darker spots on the back also. There is nothing else remarkable about it known to me. When recently taken out of the water, it inflated itself when struck."

This fish seems, therefore, to differ from that described by Mr Murray, in the dilatable belly being quite free from prickles or spines; should it turn out to be new, which seems not improbable, as I have not been able to find a similar fish described, I would take the liberty of suggesting for it the name of *Tetraodon leiógaster*—The Smooth-Bellied Tetraodon. I am unable, however, to decide the question, not having access here to various necessary authorities.

(2) *Notice of a New Genus of Ganoid Fish allied to the Genus* Polypterus (Geoff.-St-Hillaire), *recently received from Old Calabar.* By John Alexander Smith, M.D. (Specimens exhibited.)

The two specimens of fish exhibited, were sent to me with the *Tetraodon* just described, and some other zoological specimens, by the Rev. Alexander Robb, of the Calabar Mission; and in a letter, dated 28th October 1864, in which he announces the sending of the package, he states, "There are two or three small eel-like fishes." I have written to Mr Robb for more information, and hope to be able to describe these curious fishes more fully before long. They have been caught, I believe, in the fresh water of the river near Creek Town, Old Calabar, where the Rev. Mr Robb resides; and they probably live at the bottom of the river, in the soft mud; from both the specimens exhibited being pierced immediately behind the head, they seem to have been strung on a stick by the native who had captured them, and were doubtless intended to have formed part of his next meal, as Dr Hewan informs me the natives have a practice of this kind, and a taste for a varied diet, eating all sorts of fish however small.

The fish belong to the interesting Order of Ganoid fishes, and appear to be closely allied to the Genus *Polypterus* of Geoffroy-St-Hillaire, which, with the Genera, or rather Families of *Lepidosteus* and *Amia*, include the living representatives of the numerous fossil fish, the ganoids of the earlier geological epochs.

The species of *Lepidosteus* or bony pikes, and *Amia*, are found in the fresh waters, the rivers, and lakes of North and South America. Of the Genus *Polypterus*, two species were referred to by Agassiz in his "Poissons Fossiles;" he fully describes the *P. bichir*, the *Bichir* of the Nile, and notices the *P. senegalus*, from the river Senegal. Since the publication of Agassiz's great work several other species of this genus have been discovered: one, the *P. Endlicheri*, in the White Nile, described in 1849; and another, in 1857, from the rivers at Cape Palmas, on the western coast

of Africa—the *P. palmas.* In answer to inquiries, I am informed that several new species are at present in the collections of the British Museum, and were taken, I understand, in the river Nile. Some six species, or so, will therefore include all that are known as belonging to the Genus *Polypterus*, and they are all natives of the fresh waters of the great continent of Africa.

All the species of the genus appear to bear a very striking resemblance to each other. They have the body elongated, full and rounded in front (about the region of the pectoral fins), a little behind the head; and from this part it becomes more compressed in character laterally, and rapidly diminishes in breadth until it terminates in the rather broad caudal fin.

The largest species are found in the river Nile, the *Bichir* being described as measuring, when fully grown, some 2 feet or more in length. It has no less than sixteen dorsal finlets, and these commence at but a short distance behind the head. The *P. Endlicheri*, from the White Nile, has twelve of these dorsal finlets, beginning apparently at a slightly greater proportional distance behind the head.

The West African species, the *P. senegalus*, appears to be smaller in size, and with fewer dorsal finlets, which are ten in number, beginning also at a slightly greater proportional distance behind the head. While the *P. palmas*, from Cape Palmas, on the coast of Guinea, still farther to the south, and almost in the same latitude as Old Calabar, is a fish of $9\frac{3}{10}$ inches in length, has only seven dorsal finlets, and these begin at a much greater proportional distance behind the head than in the other species, being only a very little in front of the middle of the fish, measuring (in the published figure) from the snout to the extremity of the caudal fin.

The two specimens of fish now exhibited from Old Calabar, although in many of their general characters they agree with the characters of the Genus *Polypterus*, have the body much more elongated, and cylindrical in its form, and show, proportionally, less of the flattened or laterally compressed character, as in all the species of *Polypterus*. It is in this

respect almost serpent-like in its general aspect, the abdominal region of the body being very long. Its bony scales are hard and sculptured, and correspond to *Polypterus* in their general arrangement.

The Head is small and depressed towards the front, which is narrow. It becomes broader behind the eyes, where it bulges outwards laterally, becoming rather contracted again at the back part of the operculum. The upper parts of the head are covered by a series of bony plates, somewhat irregular in shape, which correspond generally to one another on the opposite sides of the head, and bear a close resemblance in their arrangement to those of the Genus *Polypterus*. Below the range of small spiracular plates, which run along the sides and back part of the head, there is a somewhat triangularly-shaped operculum, with an irregularly oval-shaped preoperculum in front of it. There are, how ever, no small plates below the preoperculum, as in *Polypterus*. On each side of the mesian line below, you have a large-sized bony branchial or jugular plate, rounded behind and pointed in front, as in *Polypterus*, which covers most of the space between the rami of the lower jaw, at least towards its anterior extremity.

A series of small perforations, or openings of mucous ducts, ten in number, surround the orbit at some little distance, running in an oval form around it; and beyond these are other sixteen openings, running in a curved direction from above downwards, along the margins of the smaller intermediate range of plates already described; others also open between the operculum and preoperculum.

The Fins are small. The dorsal finlets are very small, and apart from each other, and they begin on the back, at a great proportional distance from the snout of the fish. To show their difference in this respect from the species of *Polypterus*, I may state, that at the commencement of the dorsal finlets, the body of the fish measures about half an inch in depth, and is nearly 4½ inches in length, from the same point to the extremity of the snout; so that the distance from the snout to the commencement of the dorsal fins is about 9 times the depth of the body.

In the *Bichir*, however, it is only about $2\frac{1}{2}$ times the same proportional distance of the depth of the body to the length from the snout. In the *P. Endlicheri* it is apparently about $2\frac{3}{4}$ times the length; and in the *P. senegalus* it is about the same as the last; in the *P. palmas*, however, it is nearly 4 times as much, showing a greater approximation to the Calabar fish. These measurements of the species of *Polypterus* can, however, only be taken as an approximation to the truth, as they have been copied from the published figures of the fish, which may not be exactly correct; still there can be no doubt of the great difference in shape between them and this new Calabar fish.

Unfortunately, from the imperfect state of these Calabar fish, I am unable to carry out the comparison between them in other respects. One thing, however, may be specially noticed, that these fish appear to want the ventral fins. The bodies of these specimens have been torn across, apparently very near, or close to the anal openings, yet they show no traces of anything like ventral fins; and these fins seem to be situated considerably in advance of the anus in all the species of *Polypterus*.

From the imperfect state of the fish, however, the apparent absence of the ventral fins may be considered as still not quite determined. I trust, however, to get perfect specimens, so as to be able to settle this point at an early period, when I shall give a more detailed account of this very curious fish.

General Measurements of the Fish.

Of the two fishes exhibited, one is rather larger than the other. In the larger fish, the *head* measures about $\frac{7}{8}$ of an inch from the point of the snout to the extremity of the operculum, by rather more than $\frac{1}{2}$ of an inch in breadth across the operculum, and about $\frac{3}{8}$ of an inch in its greatest depth.

The entire length of the fish, to the extremity of its imperfect body, measures $9\frac{1}{2}$ inches, and $4\frac{3}{4}$ inches from the point of the snout to insertion of the first dorsal finlet; the second finlet is $\frac{1}{2}$ an inch distant from the first, the

others being about $\frac{3}{8}$ of an inch apart. The fins are seven in number in this imperfect specimen.

The breadth of the fish, a little in front of commencement of the dorsal finlets, measures $\frac{1}{2}$ an inch, by about the same in depth.

The smaller fish is $8\frac{1}{4}$ inches in length, the body being rather more perfect than the other; it measures $4\frac{1}{2}$ inches from point of snout to the first dorsal finlet, to the broken extremity of the fish, the finlets being eight in number.

The greatest breadth of the body is $\frac{3}{8}$ of an inch, a little behind the head, and about the same in depth; it tapers very slightly towards the first dorsal fin, and becomes more compressed laterally, towards its caudal extremity. At the fourth or fifth dorsal finlet it measures $\frac{1}{4}$ of an inch in breadth by $\frac{3}{8}$ of an inch in depth.

The *head* measures laterally, to the extremity of the opercular flap, $\frac{3}{8}$ of an inch. The greatest breadth of the head is $\frac{3}{8}$ and $\frac{1}{16}$ of an inch, and is at the junction of the operculum and the preoperculum; and the breadth between the eyes is $\frac{1}{4}$ of an inch.

From the various differences between this new fish and the species of the Genus *Polypterus*,—all of which seem to bear a close resemblance to each other in the general form of their comparatively short and fish-like body, and in the presence of ventral fins, forming thus a very natural group or genus; while the new fish, with its very much elongated and more cylindrical form of body, and apparently the entire absence of ventral fins, suggested at least the probability, of the existence, nearer the Equator, of another allied but distinct group of these African fish,—I would, therefore, place this fish provisionally in a new genus, which, from its general reptile or serpent-like aspect and form, I would designate *Erpetoichthys** (Ερπετὸν Ιχθύς), the Reptile or Serpent

* Since this paper was read, I have learned that this designation, or a closely allied one, has been already used in Ichthyology, and accordingly on the recom- Museum, I have change the name (s, a reed, and ἰχθύς, a fis which will ter of the fish.

Fish; and, following the example of those naturalists who have given the name of the locality where the fish was taken to some of the species of *Polypterus*, I would give to this new fish the specific name of *E. calabaricus*.

Wednesday, 26th April 1865.—T. STRETHILL WRIGHT, M.D., President, in the Chair.

The following Donations to the Library were laid on the table, and thanks were voted to the Donors:—

1. (1.) Memorias de la Real Academia de Ciencias de Madrid. Tomo II. 1ª Serie—Ciencias Exactas. Tomo 1° Parte 2ª 1863. Tomo III. 2ª Serie—Ciencias Fisicas. Tomo 1° Parte 3ª 1863. Tomo VI. 2ª Serie—Ciencias Fisicas. Tomo 2° Parte 1ª 1864. (2.) Resumen de las Actas de la Real Academia de Ciencias de Madrid, en el Año Académico de 1861 a 1862, por el Secretario Perpetuo Dr D. Antonio Aguilar y Vela. 1863. (3.) Los Libros del Saber de Astronomia del Rey D. Alfonso X. de Castilla, Tomo I. y II. 1863.—From the Royal Academy of Sciences of Madrid. 2. (1.) Die Fossilen Mollusken des Tertiær-Beckens von Wien II. Band, Nr 5. 6. Bivalves. (2.) Jahrbuch der Kaiserlich-Koniglichen Geologischen Reichsanstalt, 1864. XIV. Band Nro 3, Juli, Aug., Sept.—From the I. R. Geological Society of Austria. 3. Patent Office Report (United States) for 1861. Arts and Manufactures. Vols. I. and II. Washington, 1863, and Introductory Report for 1863.—From U. S. Commissioners of Patents. 4. Canadian Journal of Industry, Science, and Art. New Series, No. LV., Jan. 1865.—From the Canadian Institute. 5. Proceedings of the Royal Society. Vol. XIV. No. 71.—From the Society.

The various Committees were appointed, as usual, for special investigations during the recess.

The following Communications were read:—

I. *On the Rise of the Shores of the Firth of Forth. Have the Shores of the Forth and Clyde risen since the Human Period, as asserted by Sir Charles Lyell and Mr Geikie?* By ALEXANDER BRYSON, Esq., F.R.S.E.

The first point to which I shall call the attention of the Society is the assertion made by Mr Geikie, that as the Romans used the mouth of the Esk at Musselburgh as a harbour, and as at present no boat larger than a punt can obtain

detailed account of additional and perfect specimens of this new Genus CALAMOICHTHYS, which has no ventral fins, sp. *C. calabaricus*, see "Trans. Royal Society, Edin.," vol. xxiv. 1866.)

access to the river, therefore the land has risen in post-Roman times.

How stand the facts. The Romans built a bridge over the Esk near Musselburgh, which now forms the centre of the present old bridge. That the triremes of the Romans reached so far up no one has ever doubted who knows the history of this famous structure. It is a fact recorded in history, that at the battle of Pinkie, fought September 9, 1547, Lord Graham, son of the Earl of Montrose, was killed along with many others on this bridge by the fire of the English fleet in the offing,—at present no boat capable of conveying a small cannon could approach within two miles of the position. It is very easy to say that these are proofs of the rise of the land in post-Roman times, but Maclaren, Geikie, and Chambers have not even hinted at the cause; they have left their readers to assume, and Sir Charles Lyell to hint, that a real difference between the levels of sea and land has taken place to the extent of 25 feet since the occupation of our shores by the Roman legions. That no such abnormal action has taken place in the historic, or it may be in the human period, it will not be difficult to prove. For this purpose, I avail myself of an able paper communicated upwards of twenty years ago to the Geological Society of Edinburgh, by Mr Hay, land-surveyor, Musselburgh, and as I had the honour of being one of a committee to investigate his proofs, I have every faith in their accuracy.

The delta of low alluvial land forming the town lands of Musselburgh, or the lower part of the parish of Inveresk, to the extent of about 600 imperial acres, can be shown to have been formed by deposits in the sea brought down by the river Esk, and that the whole of these lands were sea at no very distant period of time, excepting a few small pendicles that extend into the higher ground southward. The land comprehending the formation may be considered as an irregular triangle, whose base extends from Ravensheugh Burn on the east to Magdalene Burn on the west—about two and a half miles, and whose perpendicular extends from the south end of Newbigging to the mouth of the river Esk,

—about three quarters of a mile. That on the west side of the river is in general of the most recent formation—on the Musselburgh side it is generally more ancient. The greatest accumulation has been at the mouth of the Esk, and it has diminished gradually east and west, until little or no change has taken place at the extremities of the town lands.

The frequent floods of the river Esk bring with them immense quantities of earth, sand, gravel, and stones from the hills and other lands through which it passes. The velocity of the flood is immediately checked when it meets the tide at the mouth of the river; and the matter with which the water is charged is there deposited. The same deposit must take place during the low water also. The flood in that case expands over the immense shoals already formed there, where it loses its force and leaves the materials behind—according to the general law of subsidence, the stones lowest down, the gravel in the middle, and the earth and sand upon the top. Now, at every tide when there is any wind, but more especially during northerly winds, these materials formerly deposited are thrown up by the waves upon the beach at both sides of the Esk; the gravel and sand mixed together, leaving the larger stones behind, where they form as it were a foundation to receive a new deposit.

The gravel and sand thrown upon the beach by the waves are, however, thrown no higher than the tide mark. Another agent besides the sea is therefore necessary to raise them higher in order to form the dry land. That agent is the wind that blows from the northern half of the compass, during dry weather, and low water. These winds blow up the fine sand (leaving the gravel behind) until it has by slow degrees raised the land into gentle undulations varying from nothing, to 10 feet above tide mark. A fine species of sea bent binds the sand as it is formed, whose roots gradually creep forward as the sea retires, and this bent is again extirpated by finer grass, wild liquorice, and a vast variety of other plants which follow. This bent is frequently covered with sand after a storm, but it speedily reappears. The quantity of matter brought down

by the Esk may be shown to be sufficient to have formed all the land gained from the sea, but there is reason to believe that these deposits are augmented from the land lost by encroachment of the sea between Leith and Joppa, where of late several acres have been carried off to the depth of about 20 feet, leaving large boulders upon the shore which had been formerly mixed with the soil.

Mr Hay observed the Esk, during inundations, coming down with a body of water having a cross section of at least 80 yards in area, with a velocity of three yards per second, bearing down stones of some hundred pounds weight. Now, allowing that the water was charged with only $\frac{1}{200}$th of its volume of other matter (which is a very low estimate), or 1·2 cubic yard per second, or 4320 yards per hour, and allow this to continue only ten hours annually, there would, at the end of 300 years, be deposited 12,960,000 cubic yards — a quantity sufficient to cover 400 imperial acres to the height of 20 feet 1 inch. There are some of the feu charters of the small properties in Newbigging, that declare these lands to be bounded by the sea; now, they are nearly three-quarters of a mile from the sea, with many properties intervening. The most ancient of the charters are of those lands furthest from the sea, and they become the more modern the nearer they approach the sea, till at last all those nearest the sea have been feued and built during the memory of men now living. The same may be observed of the bridges. All the land not now near the sea has been sold or given away at a nominal rent; but the land next the sea is very high in the feu-duty, having been feued after the sea had receded in modern times, when the rights of the public began to be regarded. Inveresk gives name to the parish, and signifies the mouth of the Esk. No town of any note had been nearer the river mouth when it was named. There are men who remember the sea near the mouth of the Esk being just at the north wall of what is called Chambers's Park, that is about 10 imperial chains further south than it is now. It was so deep, too, as to be a harbour for fisher boats. A field of above eight acres is now enclosed between that and the sea. They also remember the sea coming into

the ground now called Young's Yard, a little east of the present harbour, nearly 100 yards south of where the sea now reaches, at that part of the coast.

We have seen, then, that there is a part, at least, of these lands that have been formed by the recedence of the sea; and this being admitted, it is easy to show that the whole has been formed in the same manner. If the whole of the town lands of Musselburgh have been formed by the recedence of the sea, we should reasonably expect that the strata of the whole should be the same as that we know to have been thus formed; and if it is so, that circumstance alone constitutes unquestionable evidence that the whole has been so formed.

Now, we see that the whole of these lands are what may be called a dead level,—the highest knoll not rising 10 feet above tide-mark, and some of them even below that mark; for we have seen the tide at the Millhill, and even at the Cross of Musselburgh, and we see that the newly-formed land is exactly similar in these respects. When we examine the strata in the digging of foundations, wells, or such like, we find fine sand above, then fine gravel, and lastly, on the level of the mussel-bed, we find stones similar to those forming that bed, and we see that the strata of the newly-formed land are exactly the same. No other proof is required to convince us that the whole has been formed in the same manner.

The time that these lands have been in forming cannot be precisely known. Mr Hay suggests it as probable that about 400 imperial acres had been formed in about 300 years. This he calculated chiefly from analogy, drawn from his own observations for a number of years, together with the observations of others who lived before him.

We have seen there have been 10 chains gained at the mouth of the Esk in about seventy-five years. Should this breadth gradually decrease to nothing at the extremities of the town lands, we would have 100 acres gained in seventy-five years, or 400 acres in 300 years. This, however, supposes that the formation had been uniformly progressive — an assumption we are perhaps not warranted in making; so that,

upon the whole, we cannot come to an exact conclusion as regards the time. We see, however, that 600 acres have been gained by the recedence of the sea, that the sea is receding now, and if the laws of nature are unchangeable, will continue to recede until some cause puts an end to it, the reverse of that which caused its beginning.

Now, this simple appeal to facts is worth all the fanciful supposition of local upheavals insisted on by Sir Charles Lyell, Geikie, and others.*

Mr Geikie, in his paper "On a Rise of the Coast of the Forth within the Historical Period" (*Edin. New Phil. Jour.* vol. xiv. p. 102), has illustrated his communication by a section of a sand-pit, Junction Road, Leith. He states that in bed marked No. 5 in his diagram, which he calls a regularly stratified deposit of marine silt, he found fragments of Roman pottery, and that the strata with which this bed of silt is connected lie 25 feet above high-water mark, and are unequivocally those of the raised beach. He therefore infers that a rise in the land to this extent has taken place since the time of the Romans.

In a communication to the Royal Society of Edinburgh, "On Hasty Generalisation in Geology," published in the *Edin. New Phil. Jour.* vol. xvi. p. 266, and in a subsequent paper to this Society, "On the Danger of Hasty Generalisation in Geology, with special reference to the so-called Raised Sea-Beach at Leith," published in the second volume of our *Proceedings*, p. 430, I have shown that the result of careful investigations made in this sand-pit, along with my friend Dr M'Bain, convinced us, that there was no proof of any rise of the shore at Leith within the historical period, and for the following reasons, which I shall briefly recapitulate:—First, as to bed No. 5, in which the so-called

* "On a Rise of the Coast of the Forth within the Historical Period."—*Edin. New Phil. Jour.* vol. xiv. p. 102.

Smith of Jordanhill's paper on raised beaches is published in the "Edinburgh New Philosophical Journal," vol. xxv. p. 385, and in the "Memoirs of the Wernerian Society," vol. viii. Part I.; also in "Memoirs of the Wernerian Society," vol. viii. p. 58.

Robert Chambers's paper, "Edinburgh Philosophical Journal," vol. xlix. p. 233.

Roman pottery was found, and on which Mr Geikie lays so much stress, and is, indeed, the *point d'appui* of his whole argument. Instead of finding this bed to be of marine origin, and distinctly stratified, we found it to consist of two distinct beds. The lower one, which rests on gravel, is evidently a marsh silt due to the overflowing of the Water of Leith, and without remains of animals or pottery. The upper portion was distinguished from its lower congener by numerous vesicular coal cinders; and side by side with the incinerated coals we found oyster-shells, not *all* lying flat, as deposited in a bed, but at *all* angles to the horizon, precisely as any one may find them in a bed of humus. We had no difficulty of supplying ourselves with from thirty to forty specimens of pottery, also bones of sheep, the common ox (*Bos taurus*), teeth of the same, and also of the horse. The pottery was submitted to the inspection of Mr Birch, of the British Museum, the first authority we have as regards pottery. His answer was, "Not one piece of Roman origin." It was ascertained that part of this so-called Roman pottery owed its formation to a manufactory at Portobello, where elegant jugs, after the Etruscan mould, were made to hold butter-milk, and the others were the remains of neat glazed flower-pots from Holland, which, forty years ago, the skippers brought over to adorn the parlours of their wives. In this bed, No. 5, we frequently met with the stems of tobacco pipes; and five heads or bowls of pipes were found bearing the initials "T. W." On being submitted to a tobacco-pipe manufacturer in Edinburgh, and asked when they were manufactured, his reply was, "These are the initials of my father-in-law, to whose business I succeeded, and could not have been made before the year 1814, when he founded our establishment."

But another proof of this bed, No. 5, being a humus bed exists in the testimony of an old man, Thomas Anderson, who, forty years ago, cultivated this identical piece of ground as a market garden, before beds Nos. 6 and 7 were laid down.

From the Ordnance Survey map I have taken various contour levels of the streets and quays of Leith, to the

number of seventy-two. These give an average height above mean high water of 28·7 feet. Now, as the tides vary from neaps to springs about 16 feet, we must deduct from this half the amount, equal to 8 feet. This leaves for average tides a height of 20·7.

Now, as the oyster-bed of Mr Geikie, or rather his No. 1 (which I call a storm-raised bed), is 15 feet below the average of the streets of Leith, we have only to account for a storm-wave, five feet in height, to throw up this so-called raised sea-beach bed, so much insisted on by Maclaren and Chambers. Such a state of the tides has often been observed by the elder inhabitants of Leith, the effects of which could not, of course, affect land lying below the houses. But let us suppose the condition of Leith before or immediately after the Romans laid the "Fishwife's Causeway," and man had not placed barriers against the sea, but that the piers, harbours, and houses of Leith, with all their defences, were removed, old ocean would soon re-assert his former sway, and claim as his domain the Links of Leith, and leave at all high tides, and during north-east storms, effects equivalent to those which make this storm-raised bed the stumbling-block of all geologists who attempt to prove that we have any very modern evidence of a subsidence of the sea or a raising of the land.*

That the shores of the Forth at Granton have not risen since Hertford's invasion is equally evident from the history of that cruel incursion as given by Knox:—"On the 3d of May 1544, without knowledge of any man in Scotland (we meane of such as suld haif had the care of the realme) was seene a great navye of schippis aryving towardis the Firth. The postis cum to the governour and cardinall (who boith war in Edinburgh) what multitud of schippis ware seene, and what course thei tuik. This was vpon the Setturday befoir nune. Question was had, What suld thei meane? Some said it is no doubt but thei are Englischmen, and we

* Since the above was written, the bed No. 7 of Mr Geikie's section has been nearly all removed, the only portion remaining may be carried away in six or eight cart loads. The section exhibits now, what it did before, that humus and sand were alternate, as the carts which carried the stuff of the foundation were loaded anon with earth and then with sand.

fear that thei sall land. The cardinall scripped and said, 'It is but the island flote (English fleet, Calderwood); they are cum to mak a schaw and put us in fear; I shall lodge all the men-of-war in my eae (eye) that shall land in Scotland.' Still sits the cardinall at his dennare, even as that there had been no danger appearing. Men convenis to gaze upon the schippis, some on the Castell hill, some to the cragis and other places eminent. But there was no question, 'With what forces shall we resist yf we be invaded?' Sone after sax hours at nycht, were aryved and had casten anchor in the Road of Leyth mo than 200 sailles. Shortly thereafter the Admirall (Sir John Dudley, Lord Lisle) schot a flote boite, which from Granton Craggis till be east of Leith, sounded the deepe, and so returned to his schippe. Here of were diverse opinion. Men of judgement foresaw what it meant, but no credit was given to any that wold say, 'Thei mynd to land' and so past all men to his rest, as if thei schippis had been a garde to his defence. Vpon the point of day, being Soneday the 4th of Maij, addressed thei for landing and ordered thei their schippis so that a galley or two laid their snowttis to the craigis. The small schippis called pinaces and light horsemen approached as neir als thei could the great schippis dischargit thare souliors in the smaller veschellis, and thei by bottis put on dry land befoir ten houris 10,000 men. The governour and cardinall, seeing then the thing that they could nott, or at least thei would not believe befoir, after that thei had made a brag to fecht, fled as fast as horses wold carry them, so that after thei approched not within xx myles of the danger."—*From Dr D. H. Robertson's Antiquities of Leith*, p. 18.

Another fact may be mentioned here as confirmatory of the foregoing remarks. My friend Dr Paterson, well known as the assiduous collector of the fossils of Wardie, between Leith and Granton, was fortunate enough to discover an earthen jar six feet under the foundation of one of the oldest houses in Leith. The bed in which it lay was pure sand, the equivalent of Geikie's bed No. 2 (that is, blown sand). This vessel was submitted to the inspection of Mr Birch, of the British Museum, who returned as his opinion, "that its

material and style characterise it as mediæval." Now, this fact is one of some value. The age of the building under which the jar was found could not be earlier than 1544, as during its removal were found portions of the cloister windows of old South Leith Church, destroyed by the English army under the Earl of Hertford in that year, and used, as was too often the case, as a quarry for a new erection. Thus we find that Mr Geikie's bed, No. 2, was used as a foundation after 1544, when his Roman bed, No. 5, was still *in nubibus*, its sour-milk pipkins and tobacco pipes still but clay, not yet having yielded to the hands of the potter, until the year 1814.

Leaving Leith we direct our steps and observation towards the west, that is, up the river; and within three-quarters of a mile from the old bridge of the port, we come to what was wont to be called the Man-trap, half way between Leith and Newhaven. Here may be seen a fine section of the boulder-clay, 20 feet in thickness, over which lies shingle and sand, yet not a trace of the remains of even one marine shell. How comes it, we ask the supporters of the rise of the shores of the Forth, that these were omitted in this deposit, and only a single fresh-water shell obtained by a friend in our investigation of this most salient point, so important either to prove, or to disprove, the theory of which Sir Charles Lyell has become the advocate?

The next proof of the rise of the shores of the Firth of Forth is Cramond; it was occupied by the Romans as a harbour, and called Alaterva. Of this station Mr Geikie says:—" The coins, urns, sculptured stones, and other remains which have been found so numerously at Cramond, fully attest its ancient importance. The remnants of a harbour has also been detected here. It is greatly to be regretted, however, that in these, as in other instances of archæological discovery along the coast, no record appears to have been kept of the exact spots on which the remains were found. We only know that the quays which the Romans built along the sea margin have been found on what is now good dry land. No relic of the Roman period is now visible here. A rock, indeed, called the 'Eagle Rock,

or the Hunter's Craig,' is shown with the alleged effigy of an eagle carved on its eastern front, a *little above* high-water mark. Antiquarians have grown eloquent at the sight of this relic of the creative genius of the old Legionaries. But the carving has really about as much claim to be considered Roman as the famous Prætorium of Jonathan Oldbuck. Like other carvings on the shores of the Forth, it must rank among the handiwork of idle peasants or truant schoolboys." *

So far Mr Geikie.

Now, Mr Chairman, it is painful to contemplate the position of Sir Charles Lyell, who places confidence in a paper which was the result of only a few days' exploration from the Esk at Musselburgh to the Avon near Grangemouth.

Had Mr Geikie, with a true geologic spirit, set himself to study the whole question, instead of following in the wake of what Maclaren had written, and then astonishing the Geological Society with the mighty discovery that the south shore of the Forth had risen 25 feet since the Roman period, he would have saved himself a sad humiliation, and this Society the tedium of this paper. But, where older eyes and more reflective heads saw evidence of the imperial eagle on the Hunter's Craig at Cramond, he only sees the handmark of idle peasants or truant schoolboys. In short, it was a fact that would not pack into the mare's nest he had found at Leith, and so he flippantly dismisses it; and though Sir Charles Lyell has, since my first paper, not given place to Geikie's Leith mistake, he homologates the sneer against archæologists. This remarkable carving on the Hunter's Craig at Cramond is within 10 or 12 feet of high-water mark, and would necessarily not have been available to a Roman sculptor if Geikie's theory were true. But there it stands; and if this ingenious writer can produce such a carving on such a stone, with all the aid of modern tools, with his own hand, during a month, one will then perhaps believe with him, that such perseverance may yet be found among truant schoolboys. Having paid many visits to Cramond, we challenge any one to point out, even within 10

* Edinburgh Philosophical Journal, New Series, vol. xiv. p. 109.

feet of high-water mark, at the mouth of the Almond water, where Cramond is situated, one single evidence of a raised sea-beach. Again and again have we tried to find a trace of marine shells higher up than those reached by storm waves. The cause of the change of level we leave for further explanation to the end of this paper.

On one of our many journeys from Cramond through Dalmeny Woods towards Carriden, the next point in Sir Charles Lyell's evidence, we were much struck and amused by nearly stumbling over a rude canoe formed out of a single willow tree. It was much ruder, indeed, than those found below the foundations of some houses in Glasgow, having no prow to cleave the waters, and except that it bore evidence of having been cut by sharp implements, and having an iron staple for its rudder, we might have formed some new and fanciful theory other than the true one; that it was of pre-Roman origin, and not the work of the gardener's sons. Mr Geikie goes on to say:*—"The next point westwards where we meet with traces of the Roman occupation is the commencement of the Wall of Antonine at Carriden. From this point the line of the wall runs on the summit of the high bank that overlooks the Firth westwards beyond the village of Polmont. Its position at the Kerse toll-bar was pointed out to us by a farm labourer, who dug through the soil in a level field on the upper edge of the great Carse, and showed the position of the large flat stones which formed the foundation of the wall. From this locality the wall again ascended to the higher ground, passing westwards by Falkirk and Camelon, and then receding from the shores of the Forth. From Falkirk seawards, the ground forms a great expanse of flat alluvial land, called the Carse. No one can doubt that this tract has been gradually gained from the sea, and that the tides must, at a comparatively recent period, have washed the heights on which Polmont and Falkirk stand. One antiquary even asserts his belief that this tract may have been formed since the days of the Romans. He alleges, in support of this opinion, that near Camelon, on the banks of the Carron, at the inner

* Edinburgh Philosophical Journal, New Series, vol. xiv. p. 111.

edge of the Carse, the remains of the Roman Portus ad Vallum, consisting of walls, houses, and docks, existed down to the last century, and that an anchor was dug up in the same locality.*

"This independent testimony corroborates in the most satisfactory manner the geological inference already stated in this paper. I visited the site of the ancient Camelon, and found it lying at the foot of the old coast line—a wavy line of bold bluffs, similar to but considerably higher than those of the Figgate Whins. It required no force of imagination to picture the sea rising to the base of these cliffs, and ascending the valley of the Carron, with Roman galleys winding up the estuary, or anchored in the harbour of the long forsaken and forgotten Portus ad Vallum.

"Having shown that the coast at Leith has risen 25 feet or so since the Roman invasion, it by no means follows that the coast along other portions of the Firth of Forth, and of the east of Scotland generally, has been elevated to the same amount. Nor is it necessary to the truth of the conclusions of this paper, that the west coast of Scotland—as for instance at the termination of the Wall of Antonine—should be proved to have experienced any elevatory movement at all.

"Such movements are local in action and variable in amount, so that geologically there is no reason why the amount of rise may not have lessened towards the west, until in the Firth of Clyde it ceased altogether. No one can examine the shores of our country without becoming convinced that they have been raised, not by equal and uniform elevations, but by a general upheaval which varied greatly in amount in different localities, and was even interrupted by long intervals, during which the land appears to have remained stationary. Hence the raised beaches occur at different levels above the present shore, and even the same line of upheaved littoral deposits may be proved to be actually higher at one point than at another."†

* Stewart's "Caledonia Romana," p. 177.

† It is a curious fact, that during the oscillations which accompanied the deposition of the carboniferous rocks in central Scotland, a great inequality ap-

Mr Geikie's views have certainly changed very much since this was written. I read a quotation from his recent work:*—

"It might have been supposed that the comparatively sheltered estuary of the Firth would be free from any marked abrasion by the sea, yet even so far up as Granton, near Edinburgh, during a fierce gale from the north-east, stones weighing a ton or more have been known to be torn out of a wall and rolled to a distance of thirty feet. Hence, within the last few generations the sea has made encroachments, sometimes to a considerable extent, along the whole coast of the Firth, even as far up as Stirling. Tracing the southern shores in a westerly direction from Dunbar, we find that the low sandy tracts at the mouth of the Tyne, and again from North Berwick to Aberlady, have suffered loss in several places. Further on, near Musselburgh, there was a tract of land on which the Dukes of Albany and York used to play at golf in former days, but which is now almost entirely swept away. The coast of Edinburghshire has in like manner lost many acres of land. Maitland, for instance, in his 'History of Edinburgh,' describes the ravages of the sea between Musselburgh and Leith which had occasioned the 'public road to be removed further into the country; and the land being now violently assaulted by the sea on the eastern and northern sides, all must give way to its rage, and the Links of South Leith probably in less than half a century will be swallowed up. The road alluded to has had to be removed again and again since this passage was written. Mr Stevenson remarked in 1816 that even the new baths, erected but a few years before at a considerable distance from the high-water

pears to have existed between the rate of submergence in the east of the country and that in the west. During the Lower Carboniferous period (as I have shown elsewhere) the area of the Lothians probably subsided several thousand feet more than the district now occupied by the counties of Lanark and Ayr.—See *Quart. Journ. Geol. Soc.*, vol. xvi. p. 312.

* The Scenery of Scotland, viewed in connection with its Physical Geology. By Archibald Geikie, F.R.S., &c. &c. With a Geological Map, by Sir Roderick Murchison and Archibald Geikie. London and Cambridge: Macmillan & Co. 1865.

mark, had then barely the breadth of the highway between them and the sea, which had overthrown the bulwark or fence in front of those buildings, and was then acting on the road itself. Maitland speaks also of a large tract of land on both sides of the port of Leith, which has likewise disappeared. Nor are the inroads of the sea less marked as we continue our westward progress. The old links of Newhaven have disappeared. If the calculations of Maitland may be believed, three-fourths of that flat sandy tract were swallowed up in the twenty-two years preceding 1595. Even in the early part of the present century, it was in the recollection of some old fishermen then alive, that there stretched along the shore in front of the grounds of Anchorfield an extensive piece of links on which they used to dry their nets, but which had then been entirely washed away. The direct road between Leith and Newhaven used to pass along the shore to the north of Leith Fort, but it has long been demolished, and for at least fifty years the road has been carried inland by a circuitous route. The waste still goes on, though checked in some degree by the numerous bulwarks and piers which have been erected along the coast. The waves impinge at high tides upon a low cliff of the stiff blue till or boulder-clay, which readily yields to the combined influences of the weather. Hence large slices of the coast-line are from time to time precipitated to the beach. A footpath runs along the top of the bank overhanging the high-water mark, and portions of it are constantly removed on the landslips of clay. By this means, as the ground slopes upwards from the sea, the cliff is always becoming higher with every successive excavation of its sea-front. The risk to foot passengers is thus great; so many accidents, indeed, have occurred here that the locality is known in the neighbourhood as the 'Man-Trap.'

"Higher up the Firth of Forth, at the Bay of Barnbougle, a lawn of considerable extent, once intervening between the old castle and the sea, has been demolished. Even in the upper reaches of the estuary, above the narrow strait at the Ferries, the waves have removed a considerable tract of land, which once intervened between the sea and the

present road leading westward from Queensferry. Similar effects have likewise been produced on the northern shores of the Firth, at Culross and eastwards by St Davids, Burntisland, Kirkcaldy, and Dysart. The seaports along this coast have all suffered more or less from encroachments of the sea—roads, fences, gardens, fields, piers, and even dwelling-houses, having been from time to time carried away."*

On evidence as to Carriden I have a few words to say. Carriden, where the Wall of Antonine terminated, is more than 100 feet above the mean level of the Forth. Any one reading either of Mr Geikie's papers—more especially the one read to the Geological Society of London—would most naturally infer that he had seen the termination of the celebrated Roman Wall. In the above quotation he is more modest and more accurate; but for myself I did infer that a visit to Carriden would give me a long looked for pleasure to gaze on the works of men gathered to their fathers 1800 years ago.

Let me shortly detail my disappointment. On reaching Carriden, along with my friend Dr M'Bain, we announced our object to the factor on the estate, Mr Alexander Davidson. This gentleman has been on the property for upwards of fifty-five years, and is, indeed, the best authority on the subject. In answer to our queries regarding the Roman Wall, he took us to a spot near the house of Carriden, the seat of the gallant Admiral Hope, and pointed out to us the position of a tree which he had assisted in removing fifty years ago. The tree was an ash, and, on counting the circular layers, it was found to be not less than 200 years old. Now, this tree had entwined its roots round masonry which had to be removed before these could be extirpated, and then they came on the remains of what was supposed the old Roman Wall. So here we find in this paper a state-

* For further confirmation of this statement, the late William S. Young, while resident at Fillieside House, Seafield, compelled the North British Railway to give an entrance from the road south of the railway to the sea. He gained his point by proving that there was a parish road between the bottle-works at Leith and Portobello. Golf was also played within a hundred years at Bathfield, between Leith and Newhaven. Mr Whitten, in the Sheriff-Clerk's Office, can show the plans where the parish road is marked.

ment leading to the belief that the writer had seen the end of the wall, while we ascertained as a certain fact, that it had not been above ground and visible as a wall for at least 250 years. With regard to the termination of the wall near Henry Bell's monument I have nothing to say; but in regard to its eastern extremity I must remark, that it must have risen 75 feet higher than was necessary since the Roman epoch, to suit the theory of Geikie and Lyell, if the Romans meant it as a defence against the incursions of the Scots.

Further up the Forth, near Inveravon, occurs a large deposit of oyster shells. They may be obtained in cart-loads, and have furnished Mr Maclaren and others with a very feasible argument for the supposed rise of the shores of the Forth. They have contended that this bed is *in situ*, and affords all the evidence necessary to prove their position. Now, on examination of this very long-continued bed—for it appears only a little to the westward of Bo'ness then very thin and low, and increasing in depth and quantity of shells as we proceed westward, which two points I wish the Society to remember, it culminates at a point near Inveravon, a few hundred yards above a house, near the road-side, celebrated as the birthplace of the late Principal Baird of Edinburgh—how were these oysters lifted from their oozy beds and placed here at least 60 feet above high-water mark is the question, and from whence did they come? Maclaren and others affirm this as a proof of the rise of the oyster-bed to its present level, the former geologist asserting that oysters are pelagic, and only found in six fathoms water at least.

Now, what are the simple facts of this case? Let any one who hears me go to the spot, and he will find no trace of a marine bed below his sub-aërial oyster-scalp, but a fine deep bed of humus. Further, he will find 100 oyster shells of large size for one whelk or any littoral shell, proving, at least, to any one with a slight acquaintance with dynamics, that a great surging wave of translation could lift these oysters and place them in their present position high and dry when the wave retired, leaving them, as we now find them, over a fine bed of soil

which they are now enriching. Had this bed been a pelagic one, as stated erroneously by Maclaren, would we not have expected to find, if it had been rising so rapidly in the world, that it would have left some traces below of its origin? No such can be found. How, then, account for its present position? Above Queensferry, and nearly opposite, is a fine oyster-scalp, always bare at low tides. These oysters are large and plentiful, not having been ransacked by the denizens of Iron Mill Bay, where they occur. On the opposite shore the oyster shells are so numerous on the beach as to arrest the attention of the most careless observer.

Now, to account for the position of those shells 60 feet above the present highest level of the tide at Iron Mill Bay, we have this, as a recorded fact in history, that during the reign of Alexander III., as stated by Boece in his "Historia Scotorum," "in the year 1266, in the seventeenth year of that monarch's reign, a tide rose very much higher than usual—a consequence of storms—overflowed the channels of the river, especially the Tay and the Forth, and caused an inundation which overthrew many villas, laying waste the districts, and occasioned a very great loss both of men and cattle." Such a storm must have left some visible traces of its existence. Tradition, indeed, mentions one of the effects of this mighty flood in the destruction of a town and in the elevation of the sands of Barrie at the mouth of the Tay; and what, therefore, prevents us from concluding that the same mighty tempest raised from the oyster beds of Iron Mill Bay the shells which are now high and dry near Inveravon?

The "Commercial Packet," a sloop of thirty-two tons burden, laden with timber, was thrown ashore on the Hopetoun grounds, past the road, and into a field, in the year 1848.

I need not remind this Society of that great wave which occurred at the famous earthquake of Lisbon, which swept over the land, leaving vessels of many hundred tons burden 90 feet above the harbour in which they were moored. Now, this great historic wave, which took place in the reign of Alexander, though only 33 feet high below Queensferry, must have attained a greater elevation after

passing that narrow strait, and seems to us sufficiently to account for the translation of the oysters to the heights of Inveravon. All the conditions of the bed point to a convulsive movement. First, it is not by any means level, its greatest height being towards the west at Inveravon, and its lowest nearer Bo'ness; and, second, the want of any marine exuviæ below the oysters seems to me most conclusive that the bed was violently thrown up, not gradually raised. Another point is the paucity of littoral shells; for one specimen of the *Purpura lapillus*, *Littorina*, or *Buccinum*, we found 100 oyster shells. This is due simply to the effect of the greater buoyancy of the flat oyster shells, as compared to the denser Littorina.

The whole of the course between Inveravon and the Forth seems to tell, in plain language, the history of its origin, and would be eloquent, indeed, to any honest student of geology who earnestly desires truth, not fiction. It tells merely of an immense amount of detritus brought down by the rivers Forth, Teith, and Annan Water, during floods; and further, that an immense portion of this is due to the removal from its original position, and by man's hands, of Blair Drummond Moss. To these causes only we can attribute the rise of the Carse of Falkirk and the entombing of stranded whales, the bones of which have yielded for so many years an argument for the rise of our shores by upheaval from below. To this cause also we attribute all the silting up at Cramond.

It is a very curious circumstance, that the advocates of this theory of upheaval have never sought for any confirmation of it among the many islands of the Forth. At the present time a well-marked line indicates the height of the tides. There, on every rock, the Patella may be found depressing with its foot the solid rock, making, as it were, a nest for itself; but you may search in vain for any Pattellæ marks 25 feet above the sea-level on Inchkeith or Inchcolme. At Joppa hundreds of the holes of the Pholas may be seen, with the living inhabitant quietly reposing at low water in its rocky home. But no advocate of the theory of the rise of the shores of the Forth, has yet shown a hole of a Pholas with

a dead shell in it one foot above the present limit of Pholas life. But perhaps they may urge that the Lithodomi were introduced by the Romans. Until this proof is produced all their other arguments are futile.

Another argument against this theory, and I have done. The Rev. William Nimmo, minister of Bothkennar, in his "General History of Stirlingshire," published in 1787, thus describes the Roman road near Stirling:—

"The peculiar form and regular dimensions, together with the straight course, easily distinguish it from other causeways. Nearer to the Drip, too, its foundations have been lately digged up. The ford hath a firm and solid bottom, and during the summer season little above two feet of water. There was no occasion for a bridge to transport the hardy sons of Rome, whom much more stately rivers did not intimidate from their darling project of subduing and plundering the world."

If, then, this ford, as described by Nimmo, was only two feet under water in 1787, and the land had risen 25 feet, surely the legs of the horses used by the Romans must have been unusually long. This ford is still in use, and I hope will be a lasting testimony of the folly of believing that any rise has taken place on the shores of the Forth within the human period.

II. *Remarks on the assumption of Male Plumage by the Hen of the Domestic Fowl.* By WILLIAM TURNER, M.B., F.R.S.E.

The specimen shown by the author to the Society furnished an excellent illustration of the change in external characters which female birds of the gallinaceous order sometimes exhibit. It was a bantam hen, and was sent to the author by Dr Alexander Dickson of Hartree, and will be deposited in the Anatomical Museum of the University. The bird was thirteen years old at the time of death, four or five years before which it had ceased to lay eggs. About a year before death the bird began to assume the external characters of the male, which were best marked in the plumage, more especially in the form of the tail-feathers,

and in the lustre and variegated tints of the neck plumage and wing-coverts. The beak, also, was somewhat elongated, and on the left leg a well-formed spur, nearly 3-8ths of an inch long, was developed. The comb was still that of the hen. An examination of the visceral cavity showed the following state of the ovarium and oviduct:—The oviduct—the left—was pervious throughout, but contained several loose, firm, ball-like concretions. The corresponding ovarium was shrivelled, and the ova which it contained were no bigger than fine millet-seeds. Projecting into its upper part was a small tumour about the size of a pea, which sprang from the parts about the upper end of the left kidney and supra-renal capsule. Lying loose in the abdominal cavity were several small pea-like bodies, and others of a similar character were attached by short pedicles, formed of delicate connective tissue, to the outer coat of the gizzard, and one was connected close to the upper orifice of the oviduct. Each of these bodies was invested by a distinct and easily-separable capsule, and was composed of a firm, yellow, yelk-like substance, which, on microscopic examination, was seen to consist of numerous small fat-like granules.

Various naturalists have directed attention to specimens of female gallinaceous birds, more especially hen pheasants, assuming male plumage. John Hunter (Collected Works, vol. iv. p. 44), describes four hen pheasants and a pea-hen in which this change was observed. Dr Butter (*Memoirs of Wernerian Society*, vol. iii.) not only gives a very elaborate *resumé* of the various cases recorded by previous writers in which a change of plumage had been noted, but relates some additional examples, and states his opinion, which the specimen exhibited by the author confirmed, that the common domestic hen, at a certain period of life, regularly discards her dusky plumage for the more beautiful attire of the cock. Mr Yarrell (*Phil. Trans.*, 1827) examined seven hen pheasants which possessed more or less strongly-marked male plumage. Mr James Wilson (Ornithology, in *Encyc. Britannica*) considers it to be a fact in the natural history of common poultry, that all hen birds, which either by accident or design are allowed to reach the age of sixteen years,

assume the plumage of cocks; and the same change occurs in hen pheasants and pea-hens, but at more indeterminate periods of life, and less in connection with advanced age. Dr J. A. Smith (*Proc. Phys. Soc.*, Jan. 26, 1859) records the cases of three hen pheasants exhibiting the change of plumage, and at the same meeting Captain Orde stated that he had examined other specimens.

The male characters exhibited by the bantam hen described in this communication were evidently correlated with the advanced age of the bird, and may be compared with the assumption of a beard and a harsher tone of voice not unfrequently occurring in the aged human female. The atrophied condition of the ovary, and the necessary cessation of ovulation, are also to be ascribed to the same cause. Previous writers have directed attention to the not unfrequent occurrence of an atrophied or diseased condition of the ovaries, or an obstructed state of the oviduct, in hen birds possessing male plumage, and this not only in aged birds, but in young specimens. So that the change of plumage would appear, in these cases at least, to be correlated with an impairment or complete stoppage of the ovarian functions, though it should be stated that some isolated instances have been recorded, as in one of the hen pheasants described by Dr J. A. Smith, in which the ovaries were perfectly healthy, and contained numerous ova.

The author considered that the loose bodies found in the abdominal cavity, as well as those of a similar structure attached by adhesive bands to certain of the abdominal viscera of the bantam hen, were aborted or degenerated ova, which had not entered the ovarian duct, but had escaped into the peritoneal cavity, and had either remained free, or had assumed connections to adjacent viscera. A. W. Otto (*Seltene Beobachtungen*, Breslau, 1816, p. 137) appears to have met with a body of a similar character, but of much larger size, in the peritoneal cavity of a hen he examined. It was invested with a false vascular membrane, and possessed a distinct capsule containing a yellow yelk-like substance. He regarded it as a degenerated ovum.

III. *Notice of the Anatomy of the new Ganoid Fish from Old Calabar, described by Dr John Alexander Smith at last Meeting.* By RAMSAY H. TRAQUAIR, M.D.

Dr Traquair had received from Dr Smith several specimens of these curious fish, to be carefully dissected and examined, and then placed for preservation in the Anatomical Museum of the University; the fish, however, had only recently been put into his hands. He had not yet had time to make a detailed dissection of them. As far as the abdominal viscera were concerned, however, they appeared to agree with those of the *Polypteri* already described.*

IV. *Notice of the occurrence of double or vertical Hermaphrodism in a common Cod Fish,* Morrhua vulgaris, *recently taken in the Firth of Forth.* By JOHN ALEXANDER SMITH, M.D. (The specimen was exhibited.)

Dr Smith stated he was indebted to Messrs John Anderson & Son, fishmongers, &c., Royal Emporium, George Street, for sending him this very interesting specimen.

Mr Anderson, in his note says, it seems to have both the male milt and the female roe, and is the first of the kind that has ever come under our notice.

The cod was taken in the beginning of April, and was not remarked as being different in any way, externally, from the other well-developed specimens of cod fish. The generative organs were small, but apparently of nearly the ordinary size of other fishes at this season of the year. They consisted of a perfect roe or ovary, on the left side of the body, measuring 4¼ inches in length, by about 1¼ inch in its greatest breadth, with a distinct and perfect oviduct attached; on the right side, however, the organ was compound, consisting in its upper part of a second and smaller ovary, measuring 3 inches in length, by about the same breadth as that of the left side; and lying immediately below it, and surrounding the oviduct, were the numerous lobes of a milt, measuring about 5¾ inches in length, by

* A detailed account of the anatomy of this fish has since been published in the Proceedings of the Royal Society of Edinburgh, vol. v. 1862–1866.

about $2\frac{1}{2}$ inches across the artificially expanded lobes. These lobular masses communicated on all sides with the oviduct which passed through them, by numerous small openings of tubes, apparently extending outwards into the lobes of the milt. On examining with a microscope of low power the mass of the roe, numerous small but apparently perfect ova were distinctly visible; and on examining the milt with a power of 480 diameters, distinct rounded or oval-shaped bodies of small size were seen in great numbers, but showing no appearance of tails, or cells.

This specimen is therefore an instance of what has been designated true hermaphrodism, certain of the male and female organs being blended together in the same individual. Only in it the generative organs on one side of the body, the left, are apparently perfectly female; and on the other they appear to be combined female and male. It may, therefore, be described as an instance of complex, double, or vertical hermaphrodism, as it has been designated.

Dr Smith referred for further information on the general subject to the learned and elaborate paper on Hermaphrodism in all its varieties, by Professor J. Y. Simpson, in "Todd's Cyclopædia of Anatomy," 1839, vol. ii.

Professor Simpson says:—"Various instances, however, are on record of fishes known to be normally bisexual, presenting from abnormal development a lateral hermaphrodictic structure, or a roe on one side and a milt on the other. Such a hermaphrodictic malformation has been met with in the genera *Salmo*, *Gadus*, and *Cyprinus*, and in the *Merlangus vulgaris*, *Acipenser huso*, and *Esox lucius*."

The references given to these recorded instances of hermaphrodism in fish, strange to say, are apparently all to various foreign journals.

This instance differed, however, from any of the cases here referred to, and was a distinct instance of complex or vertical hermaphrodism, and Dr Smith had not been able to find any example of this hermaphrodism in the cod fish, recorded in any British periodical or publication.

He had, therefore, much pleasure in presenting this apparently rare specimen to the Anatomical Museum of the

University, and hoped that a minute anatomical and microscopic examination of it would be made.

V. *Anatomical Description of the Complex Generative Organs of a Cod Fish.* By Ramsay H. Traquair, M.D.

Dr Traquair made some short remarks as to the anatomical details of this peculiar state of the generative organs, which, however, he had not been able as yet to examine very particularly.

VI. *Notice of various specimens of the deformed variety of the* Morrhua vulgaris, *the common Cod Fish, the Lord Fish of Yarrell, recently taken in the Firth of Forth.* By John Alexander Smith, M.D. (The specimens were exhibited.)

Dr Smith said he was indebted to Mr Charles Muirhead, Queen Street, for the specimens of the peculiar deformed-looking cod fish now exhibited; this fish was figured and designated by Yarrell, in his "British Fishes," vol. ii., as the *Lord Fish*, and was generally considered as an accidental deformity, due, as was formerly shown to the Society in December 1855, by Dr T. Spencer Cobbold [see *Proceedings*, vol. i. p. 51], to a remarkable shortening and coalescence of some of the vertebræ, from disease, giving it thus a sort of humpbacked appearance.

A carefully detailed account of the same peculiarity has also been given by Dr Robert Dyce to the British Association at its meeting in Aberdeen in 1859, which was published in the "Annals and Magazine of Natural History" for 1860.

Dr Dyce, in his communication, also shows that the peculiarity of shape is due to disease, and points out the identity of Yarrell's "Lord Fish" with the *Morrhua vulgaris*, and also with the "Speckled Cod," the *Morrhua punctata* of Turton's "British Fauna," 1807.

The strange peculiarity, however, and one not easily explained, lay in the fact stated to him by Mr Bargh, Mr Muirhead's assistant, that these fish were not uncommon at this particular season of the year, and that in a take of six or

seven dozen cod from the long lines baited with the lug-worm, and laid on the north side of the Firth of Forth, between Kinghorn and Inchkeith, on the 18th instant, no less than six or seven specimens of this peculiar variety were taken. These varied in size from about 4 to 17½ inches in length, and were presented by Dr Smith, for further examination, to the Anatomical Museum of the University.

VII.—*Notes of several Recent Contributions to the Zoology of Old Calabar*:—1. Galago Demidoffii. 2. Chameleon fasciatus, *n. s.*? 3. *Various insects, with "Notice of an apparently undescribed species of* Orthopterous Insect *of the family* Gryllidæ, *and other Insects*, by Adam White, Esq." By JOHN ALEX. SMITH, M.D. (Specimens were exhibited).

1. *Galago Demidoffii?*

Dr Smith said the first of these recent contributions from Old Calabar he would exhibit were two male specimens of a very curious and interesting *Galago*, probably the same as that described by Mr Murray in the "Edinburgh Philosophical Journal" for 1859, as *Galago murinus*, or mouse-like *Galago*. The figure given by Mr Murray differed slightly from this specimen, perhaps merely due to the finer condition of the one now exhibited, the tail being also much larger and fuller.

Two specimens of this Galago were exhibited, one of them being in very fine preservation. The general colour, of the specimens preserved in spirits, is the head and upper parts dark brown, with a tinge of reddish-brown on the extremities of the hair; the ears rather lighter, or reddish-brown; a broad stripe of white runs down the ridge of the nose from between the eyes, to its white and naked extremity, where it divides and surrounds each side of the mouth; the under lip is also apparently edged with white. The colour of the extremities is lighter and more of a reddish-brown.

Below, the colour is dark grey, the points of the hair being lighter, and the inner sides of the extremities are of a light grey or white.

This little animal measures about 8¼ inches in total length.

The *Body* along the dorsal surface measures, from snout to root of tail, $4\frac{4}{20}$th inches; the head, $2\frac{1}{20}$th inches, from back of head to root of tail, $2\frac{3}{20}$th inches; length from snout to root of tail in a straight line, $3\frac{4}{20}$th inches. The tail measures $4\frac{11}{20}$th inches in length, and to the extremity of the hair $4\frac{17}{20}$th inches: and taken from the spirits the creature weighs one ounce avoirdupois.

The *Head* is full and rounded, and the snout short and rather pointed; it measures in a straight line $1\frac{5}{20}$th inch in length, by $\frac{16}{20}$ths of an inch in greatest breadth behind the ears. Eyes large and full.

There are a few scattered black bristles or longer hairs projecting from each side of the nose, and one or two also behind the eye, between it and the ear.

The *Ears* are somewhat oval in shape above, measuring nearly $\frac{3}{4}$ths of an inch in length by about $\frac{8}{20}$ths of an inch in greatest breadth; they are covered with very short hair externally, and are nearly naked on their inner surface.

There is a single transverse plate or lamella projecting above the auditory meatus; it measures $\frac{2}{10}$ths of an inch in length, by $\frac{1}{10}$th of an inch in breadth or projection. Dr S. stated that in the Angwantibo of Old Calabar, the *Perodicticus Calabarensis*, as he designated it, which he had formerly the pleasure of bringing before the notice of this Society, the ear had two of these transverse lamellæ. Dr J. E. Gray, of the British Museum, has since set apart the Angwantibo, he believed very properly, as a new genus *Artocebus*, so that it is now named the *A. Calabarensis.*

The limbs are covered with hair, becoming shorter towards the distal extremities, and extending even to the extremity of the distal phalanges, which are naked below.

The hand or forefoot has the second or index finger the shortest, the fifth next in length, and the third and fourth nearly equal, but the fourth slightly the longest.

The *anterior extremities* measure in length:—The arm, or humerus, about $\frac{13}{20}$ths of an inch; the forearm, or radius and ulna, $\frac{17}{20}$ths of an inch; the hand, to extremity of the

the fourth finger, $\frac{13}{20}$ths of an inch ; and the greatest breadth of hand across root of thumb is $\frac{9}{20}$ths of an inch.

The hind foot has the second or clawed toe the shortest, the fourth the longest, and the third and fifth nearly equal.

The *posterior extremities* are longer than the anterior. The thigh, or femur, measures $\frac{18}{20}$ths of an inch ; the leg, or tibia, $1\frac{4}{20}$ths inch ; the tarsus and foot, $1\frac{9}{20}$ths inch ; the tarsus, $\frac{15}{20}$ths of an inch ; the foot, $\frac{14}{20}$ths of an inch ; greatest breadth of foot across ball of great toe, $\frac{9}{20}$ths of an inch.

The *Tail* is thick and bushy ; it becomes thicker at about a third of its length from the root, and continues bushy for about another third, from whence it tapers gradually towards its distal extremity.

The second specimen is not in such fine condition ; it is also a male ; the measurements of its body are about the same as those of the other specimen.

$$\text{The teeth are—}\quad i.\ \frac{2\ \ 2}{4},\quad c.\ \frac{1}{1}\cdot\frac{1}{1},\quad m.\ \frac{4}{4}.$$

The molars apparently only $\frac{4}{4}$, the others as yet not being developed above the gum ; the sutures of the skull, however, are completely ossified. In the first specimen the molars are more numerous, probably $\frac{6}{6}\ \frac{6}{6}$, but it is not easy to examine them carefully without injuring the specimen.

There were, Dr Smith believed, no examples of this curious little *Galago* in our National Museum of Science and Art, so he had much pleasure in presenting these specimens to that valuable collection.

Dr Gray, of the British Museum, had recently published a monograph of this interesting group, in which he classes Mr Murray's specimen as the young of the *Galago Demidoffii*.

This Old Calabar Galago is therefore apparently the same species as the *Galago Demidoffii*, Fischer, as given in Dr J. E. Gray's revision of the Genera, published in the "Proceedings of the Zoological Society" for 1863. In the same volume, however, there is a communication by Dr W. Peters, stating that Fischer's *Galago Demidoffii* is simply the young of Temminck's *Otolicnus peli*.

It has been found, apparently, in Senegal, Old Calabar, and the Gaboon.

Dr Smith quoted the following account of the cry of the creature from a letter he had received from Mr Hewan:— "This cry it is difficult for me to describe. Of all sounds that I can think of, the most like is that of a cricket, but more intensified. It runs steadily up the musical scale, and embraces about two octaves, or rather more, increasing in rapidity towards the end, and the whole in well finished staccato."

2. *Chameleon fasciatus*, n. s.?

Dr Smith exhibited a specimen of chameleon, which differed from the common species, and might be new. It apparently belongs to the Genus *Chamæleon* of Dr Gray's "Revision of the Genera and Species of the *Chamæleonidæ*," just published in the "Annals of Natural History."

This chameleon has the nose simple, and the occiput slightly produced and rounded, with a raised central keel, and an oval-shaped depression pointing outward and forward on each side of it; the upper part of the head and occiput are covered with flat, somewhat hexagonal-shaped scales, and the rest of the head with rounded ones. There is a small distinct flap projecting behind and on each side of the occipital protuberance; which is covered with large rounded scales. The head is light-coloured above, with a twin spot of black in front, and is mottled transversely with grey and white on the sides; it measures, $1\frac{4}{20}$ths of an inch in length from point of snout to extremity of occipital protuberance; from point of snout to front of orbit, it measures nearly $\frac{8}{20}$ths of an inch, the orbit across nearly $\frac{8}{20}$ths, and from back of orbit to extremity of occipital protuberance $\frac{10}{20}$ths of an inch. The small occipital flap projects about $\frac{1}{20}$th of an inch beyond the protuberance, and measures altogether about $\frac{4}{20}$ths of an inch across. There is no distinct dentated crest on the back, chin, or belly; a yellowish-white stripe of scales, becoming larger and more distinct on the abdomen, extends from the chin to the anus. The scales of the body are unequal, larger ones being scattered over the sides, and all

the extremities. The general colour of this chameleon, preserved in spirits, is bluish-grey, mottled with lighter, and spotted over with reddish-yellow and white. The colours are principally thrown into transverse bands, alternately light and dark, approaching to black, some nine or ten of which may be counted between the neck and extremity of body. The tail is also crossed by alternate fainter bands of light and dark grey.

The body measures laterally 4½ inches in length from snout to anus, and the tapering tail 6¼ inches in length from the anal opening. Should the specimen turn out to be new, which, however, from the want of various specimens to compare it with, he was unable finally to determine, he would be inclined to suggest for it the designation of the banded chameleon—

Chamæleon fasciatus, n. s. ?

Dr Smith trusted, however, to be able to bring the specimen under the examination of Dr J. E. Gray of the British Museum, our first authority in such matters.

The chameleons found at Old Calabar, in addition to the one now exhibited, were, Dr Smith said, the *Chamæleon* or *Pterosaurus cristatus* of Gray, two specimens of which had been already exhibited by him to the Society ; and the three-horned chameleon (*Chamæleon tricornis*) exhibited by Mr Andrew Murray in 1860.

Mr Hewan had sent him some notes on the chameleon, and describes a curious African superstition in reference to those found at Old Calabar. He writes as follows :—

"Altogether I don't think I have seen more than six or seven. The fringed one is certainly the most common, so far as I have noticed, but I have seen others also. This, as I have said, is a matter for future investigation. . . .

"The superstition with reference to the chameleon is this : Should a person going along the road meet a chameleon and kill it, he must place it in some conspicuous place there, and to do so as definitely as he can he collects a few green leaves, and places them over the dead body of the reptile. Every person passing the spot is thus enabled to take

notice of the fact, and is bound to put additional leaves to the heap. Whoever omits to do so will certainly die in the course of the following seven years. The native name is *Ŏk'-u-bé.*

"With respect to the changes of colour that I have witnessed, my attention was first attracted to the creature while going along the road. Seeing what seemed to me to be a leaf (because it was of the same colour as the leaves lying all around it), moving slowly along on its edge, my attention was arrested, and I stooped down to observe more closely what I thought was a strange freak for a leaf, and what was the motive power. I soon saw it was altogether a living creature, and in an instant more that it was a chameleon. I had never seen one at large before, and was delighted, as you may imagine, with such an introduction to it. By this time, finding that it was being very closely noticed, it changed its hues gradually but steadily from one tint to another, keeping at the same time its little round eye firmly fixed on me. It readily fastened itself on my walking-stick, and I took it home. Happening to have a small wooden cage at hand, I put it in, and put small bits of meat there, hoping to attract flies, on which it would be enabled to support itself, but no flies came. In three weeks the beautiful round orbits had very sensibly shrunk, and became much too small for their sockets, and altogether the whole body of the poor little creature had become very pitiably emaciated. All our efforts to make it eat proved unavailing. There, like ——, 'it pined, with a green and yellow melancholy,' and so to put an end to its misery, I put it in spirits, and brought it to you.

"Of its change of colour; during the time it remained in the cage I had constant opportunities of witnessing this. The colours into which it would put itself, and which were uniform over its body, were green, chocolate brown (the colour of the leaf on which I first saw it), a dull dark approaching to black, and a pale ash or drab colour. But generally it assumed a mottled appearance, blending several colours—yellow, red, green, and black, &c., so far as I can recollect. Both sides were not always similarly coloured. I have seen it quite dark on one side, and pale drab on the other at the same moment, as well as other diversities."

3. *Various Insects.*

Other creatures of interest were exhibited ; the most important, however, belonged to the family of insects, and in reference to the first of these, Dr Smith said—Unfortunately, he could not get access to a copy of the "Fauna of the Gaboon," published by Mr Thomson of Paris. If the curious insect now exhibited be not described in that work, it does not appear to be recorded in any work he had consulted, nor does Mr Adam White, to whom he had shown it, know of any figure or description of it. Mr White has kindly given the following note, which will enable it to be identified:—

"*Notice of an apparently Undescribed Species of* ORTHOPTEROUS *Insect of the Family* Gryllidæ, *and other Insects from Old Calabar.* By ADAM WHITE, Esq.

"This curious insect belongs to the group *Camptoxiphæ* of the section *Locustariæ*, as characterised by Serville, in his work on Orthoptera. In this group the oviscapt forms a short, bent, broad blade. The present genus, of which I have only seen a female, is allied to *Phaneroptera*, and has some general points of agreement with the genus *Markia*, founded on the *Phaneroptera hystrix* of Westwood. (See 'Museum of Natural History,' ii. p. 244.)

"ACRIDOXENA,* n. g., *White.*

"*Head* large, simple ; eyes small, prominent. Labrum large, rounded.

"*Prothorax* with the lateral edge of its back six-spined, the front two-spined ; the *mesothoracic* plate, square in front, and deeply sinuated behind, edge projecting into a spined lobe ; *metathoracic* plate wider than long, widely lobed behind ; the lobes leaving a wide square notch, lobes spined.

"*Tegmina* (in the female) sinuated on each of the lateral margins, the posterior portion forming a broad lobe, rounded behind.

"*Wings* slightly larger than the tegmina ; the outer margin sinuated and extending at the end into a narrow lobe.

* Ξενος and ακριδα, strange or curious Acrida

"*Legs*, anterior and middle pair with a foliaceous appendage on the femora and tibiæ, that on the femur extending from the middle to the end, the appendage on the tibiæ narrower, and at the base—all the femora with two rows of spines. Tibiæ of hind legs with one row of spines in front and two behind."

A few words may describe the solitary specimen of the species:—

"Tegmina and part of wings covered by them, like a brown withered leaf. Wings deep black, edge near the lobe spotted with white. A small, smooth, black spot near the posterior edge of tegmina. The thick jaws are yellow at the base, and black inside and at the apex.

"Length front of head to end of oviscapt, 3 inches.

"Length of wings, 1 inch.

"Expanse of tegmina, 3 inches and 1 line.

"Length of fore legs, 2 inches and 6 lines.

"Length of hind legs, 4 inches and 3 lines.

"*Hab.* Old Calabar.—Its large, powerful head and jaws show that it must be a voracious feeder of leaves of a stronger texture than those of our shrubs and trees."

"Of the Family *Locustidæ*, which contains the migratory locusts and our grasshoppers, there is a curious short-winged insect, allied to *Petasia* and *Phymateus*. The tegmina and wings are only about half the length of the body.

"A brilliant little blue and green *Chrysis*.*

"A curious black bee,* with black wings, thorax below whitish, legs hairy and rough, and very long maxillæ. He hoped Dr Smith would send it to Mr Frederick Smith of the British Museum, who has such a perfect knowledge of the Hymenoptera.

"Of the *Diptera*, there are two specimens of a most cosmopolite genus, *Tabanus*,* flies whose attacks on cattle are so

* Dr Smith has since sent the bee to Mr F. Smith, and is informed that it is the female of a new species of *Anthophora*. The *Tabanus*, Mr Smith also says, is the *T. tibialis*; and the beetle mentioned above is the *Stilbum lyncea*.

well known, and its habits seem to be very well known to the natives, whom it attacks in clouds when going up the rivers in their boats; this specimen has formidable jaws, is of a pale or light brown colour, with three longitudinal bands of darker brown, along the upper part of the thorax ; abdomen yellowish brown, with narrow transverse bands of black; wings pale brown.

"Of the *Hemiptera* and the Family *Reduviidæ* there is a large species of *Platymerus*, much larger than the *P. biguttatus* (Linn. sp.)

"It has two red spots on the base of the hemelytræ, which have a few small spines. The legs have also larger pale rings on them."

"A specimen of the *Platymerus biguttatus*, with its powerful curved proboscis, inflicted a severe wound on the arm of the Rev. Mr Morgan at Sierra Leone, whose arm swelled up in an hour or two, in consequence, to nearly twice its size.

"LEPIDOPTERA *Fam.* BOMBYCIDÆ.—The case of an *Oiketicus* is in the collection, that curious group of the family, the female of which is apterous, and constantly lives in a case or house. Only some five species are described of the singular genus, and they occur principally in the West Indies. He hoped, in some subsequent collection, the winged male of it would be found."

Dr Smith said he had received this *Acridoxena*, along with the other insects, from Mr Archibald Hewan, the surgeon to the U. P. Mission at Old Calabar. This specimen was the only one he had seen. The antennæ, which were unfortunately now broken off, were very long and slender, longer, he believed, than the whole body of the insect; and as Mr White had refrained from naming the species he had so well described, he would, in compliment to Mr Hewan, who had been so zealous in collecting and sending home various interesting objects of natural history, designate this very curious insect the

Acridoxena Hewaniana, n. s.

The very handsome black-spined *Platymerus* may be named in compliment to the Rev. Alexander Robb, Old Calabar, who recently sent Dr Smith the new ganoid fish before referred to, and many other specimens of much interest—

Platymerus Robbianus, n. s.

It measured nearly $1\frac{3}{4}$ inch in total length, by $\frac{6}{10}$ths of an inch across the abdomen. The hemelytræ measured $1\frac{2}{10}$ths inch in length. The thorax above is covered with various strong projecting spines, and three or four small spines project on each side from the lateral margins of the abdomen.

The usual Committees for special investigations during the summer, were appointed. A vote of thanks was given to Mr George Logan, on his resigning office, for his valuable services while Convener of the Dredging Committee.

Thanks were voted to the office-bearers, and the Society adjourned to the beginning of next winter session.

ERRATUM.

Page 296, *for* Annan Water *read* Allan Water.

PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

NINETY-FIFTH SESSION, 1865-66.

Wednesday, 22d November 1865.—DAVID PAGE, Esq., President, in the Chair.

The following Donations to the Library were laid on the Table, and thanks voted to the Donors:—

1. Palæontology of Niti, Northern Himalaya, by J. W. Salter, F.G.S., and H. F. Blandford, F.G.S. 2. Journal of the Proceedings of the Linnean Society, Parts 29 to 34.—From the Society. 3. Proceedings of the Royal Society, Nos. 74, 75, and 76.—From the Society.

The President, Mr DAVID PAGE, then delivered the following Address:—

In opening the business of another Session, I offer a few remarks on

"MAN'S PLACE IN THE GEOLOGICAL RECORD,"

from the conviction that the subject is at present unfairly dealt with, and treated with unnecessary reserve. As is often the case with topics of novelty, certain observers are evidently carrying the question beyond its legitimate domain; while others (perhaps the more competent), alarmed by this indiscretion, are timorously abstaining from the discussion, and as evidently withholding their matured convictions. Under such circumstances, no progress can be made: truth can never be arrived at. As a question of Natural Science, the subject is surely as open to investigation as any other that comes within the scope of human research, and may be discussed as fully and freely, if we

would only restrict ourselves to facts, and be governed by scientific methods. Under this conviction, I offer the following remarks. If to some they shall seem inconclusive; to myself, at least, they appear as explicit as the facts will warrant, and the topic throughout has been dealt with in the same manner as would any other that comes legitimately within the scope of geological inquiry.

Unlike the periods of human history, those of Geology have no definite expression in years and centuries. We speak of eras and epochs, of cycles and systems, but these are merely relative terms. They have no definite duration; the one merely precedes the other, and the larger may include many recurrences of the lesser within its limits. In speaking of geological time this is all that is signified; in fixing the dates of geological events this is all that can be fairly asserted. The Primary merely precedes the Secondary, the Secondary the Tertiary, and the Tertiary the events of the current epoch. We may subdivide these greater stages into narrower limits, and talk of Laurentian, Cambrian, Silurian, Devonian, Carboniferous, Permian, Triassic, Oolitic, Cretaceous, Tertiary, and Recent rock-systems, and this is no doubt restricting events to more precise bounds; but it gives no definite idea of duration, nor tells us how long the Chalk preceded the Tertiary, or the Tertiary the occurrences of the existing epoch. We can judge from its thickness, and the nature of its rocks and fossils, that one system took much longer time to accumulate than another, but we cannot venture, by any known method of computation, to say how long in years. All that we have to do with is relative time; and even in dealing with the current epoch, should we assert that certain events took place more than six thousand or eight thousand years ago, we are simply asserting a provisional opinion, and not maintaining a belief like that founded upon the written record of human history.

The geological history is thus relative and not absolute, and when we arrange it, as in the subjoined tabulation, into Primary, Secondary, Tertiary, and Quaternary, we are merely asserting a certain order of succession, and this succession not always clearly defined over certain areas. In-

deed, it is often impossible to define the boundaries of the minor stages, portions having been removed by denudation, others overlaid by more recent deposits, and some being partially submerged beneath the waters of the ocean. Again, though the thickness of one formation may seem to have required a longer time for its accumulation than another of smaller dimensions, yet in the one case the rate of deposition may have been much more rapid than in the other, and the thinner may, after all, have required the longer period. Still further, though organic remains are most important aids, yet they are often absent from certain beds, or if there, these beds are not sufficiently exposed to investigation, and our information becomes in this way fragmentary and defective. Neither in sequence of events, nor in expression of time, does Geology lay claim to exactitude. Its cultivators are successfully labouring to complete the one, and they are hopeful of arriving at more definite terms in the other; but this is all in the mean time, and the following arrangement expresses the amount of their information:—

CAINOZOIC (*Recent Life*).	Quaternary or Recent formations. Tertiary.
MESOZOIC (*Middle Life*).	Cretaceous or Chalk. Oolitic or Jurassic. Triassic or Upper New Red Sandstone.
PALÆOZOIC (*Ancient Life*).	Permian or Lower New Red Sandstone. Carboniferous or Coal System. Old Red Sandstone and Devonian. Silurian.
EOZOIC (*Dawn Life*).	Cambrian. Laurentian.

In this arrangement the terms Eozoic, Palæozoic, Mesozoic, and Cainozoic, indicate the chronological stages having reference to the ascent of life; and Laurentian, Cambrian, Silurian, &c., those having reference to the different formations whose depositions mark the successive physical operations of nature. By this arrangement the geologist simply asserts that the Laurentian preceded the Cambrian, and the Cambrian the Silurian, but no opinion is expressed as to the amount of time required for the deposition of the Lau-

rentian, or whether the Cambrian occupied a longer time in formation than the overlying Silurian. We may feel convinced, from the total thickness of a system, the alternations of its strata, and the succession of its fossils, that it occupied a much longer time in formation than another system; but this is not expressed in the above arrangement, which merely affirms a sequence from older to younger, and from the earliest ascertainable operations to those still taking place around us.

Such is the chronology of Geology—a chronology to which investigators endeavour to conform the rock-formations of the globe; and although the Chalk of one country, for example, may not have been exactly contemporaneous with the Chalk formation of another region, still we know that it stands intermediate between the Oolite and Tertiary, and can therefore assign to it a place relatively to these formations. In some region yet unexplored a whole suite of strata may be discovered older than our Carboniferous, and yet younger than our Old Red, and in such a case geologists would give the new formation a name, and place it as intermediate between these two systems. It would disturb no established order, but merely render more complete the sequence, like the interpolation of a hitherto unknown reign in the dynasties of human history. The geological record is thus a thing of mere sequence—an inconceivable amount of unexpressed time, during which certain events follow each other in definite order. How many ages have elapsed since the first deposition of the Laurentian strata we cannot tell; how many centuries were spent in the formation of the Coal-measures of any locality, we can only, estimating from existing operations, offer the widest conjecture. But we can affirm with certainty, and this is a great point gained, that one rock-system is younger than another; that these rock-systems follow in the order above given; that according to our present knowledge invertebrate life preceded the vertebrate; that fishes preceded reptiles, reptiles birds, and birds mammalia. We can also affirm, what it is the object of the following remarks to prove, that as there has been an ascent in time from lower to higher forms of life, so Man,

being the highest known creature, comes latest on the geological stage, and that evidences of his existence are to be found only in the most recent and superficial formations.

It will be seen from the preceding statements that the geological record is avowedly indefinite and defective—indefinite, as it deals only with relative time; and defective, as many strata cannot be assigned to their proper positions, partly from the obscurities of superposition, and partly from the absence of typical fossils to connect them. But, while admitting this defect in details, it must not be imagined there is any uncertainty as to the broader features of the record, or that any new discoveries have ever been at variance with the great order of sequence which modern geology has established. Man, so far as every known fact tends to indicate, belongs exclusively to the Recent or Quaternary period. No remains of his kind, no fragment of his works, no trace of his presence, have ever been detected in earlier formations. But though this is admitted on all hands, the question still remains, at what stage of the Quaternary are traces of his existence first detected? Till recently the general belief has been that man's first appearance on the globe dates back, at the very most, to little more than six or seven thousand years; and so incorporated had this belief become with others of a more sacred character, that few, even though doubting, had the boldness to express a contrary conviction. Like the age of our planet, which was also at one time restricted to a few thousand years, the antiquity of man has become a question of science and reason; and well-informed minds are now prepared to admit, that as the earth has existed for untold ages, so man, its latest creation, may have inhabited its surface for hundreds of centuries. The evidence is purely geological, and as such ought to be treated like any other problem in science, without bar or hindrance from preconceived opinion; or, as it has been well said by the Bishop of London, in his late address to our Philosophical Institution, "The man of science ought to go on honestly, patiently, diffidently, observing and storing up his observations, and carrying his reasonings unflinchingly to their legitimate conclusions, convinced that

it would be treason at once to the dignity of science and of religion, if he sought to help either by swerving ever so little from the straight rule of truth." In investigating the antiquity of man we are dealing with a question of natural history, and are bound by the same methods of research as if we were treating of the history of the mammoth or mastodon. Our business as geologists is to examine the rock-formations composing the earth's crust, to note their imbedded organisms, and to fix their relative antiquities. Wherever the remains of man or of his works occur, there, we presume, has been his presence; and though we cannot assign any definite date to the time of such occurrence, we are at all events entitled, judging from all the correlative circumstances, to say that it took place more than six thousand, ten thousand, or twenty thousand years ago. In other words, we are bound to deal with Man's antiquity as with any other question in geology; and though our dates be merely relative, we can affirm the order of sequence, and arrive at some notion of duration from the rate of existing operations.

Abiding by these methods, we find the remains of man and of his works gradually receding from the historical into the pre-historic ages. In Southern and Western Europe—the only regions that have been examined with anything like geological accuracy—these remains occur in peat-mosses, in lake silts, river-drifts, and cave-earths, and from their associated organisms we judge of their relative antiquities. If they occur along with the remains of the existing horse, ox, sheep, pig, and the like, we know that they are comparatively recent, and in all probability belong to the historic era. If, on the other hand, they are found accompanied by remains of extinct species of horses and oxen, we know they are of greater antiquity; and if such horses and oxen are not spoken of in history, or represented in human monuments, then we are entitled to regard them as pre-historic. Or again, if they are associated with remains of the great Irish deer, the mammoth, mastodon, woolly-haired rhinoceros, and other animals long extinct, we feel assured that vast changes in physical geography have taken place since their

entombment, and are entitled to assign to them a still higher antiquity. In fact, we know that all changes in physical conditions, and all removals and extinctions of life, take place by slow and silent stages, and that the greater the difference between the existing and the extinct, the longer must be the time that has elaped since their extinction. By methods such as these we can establish a scale of old, older, oldest; and there need be no more uncertainty about the results obtained by such methods than there is about the results obtained by the historian in modern, medieval, and ancient history.

Another method by which we arrive at notions of relative antiquity is by the implements and works of art that occur in recent formations, or accompany the remains of man. We know the phases of modern, medieval, Roman, Greek, Egyptian, and Babylonian art, and can assign something like a historical date to such objects and the accumulations in which they occur. We know, too, that man employs tools of wood and stone long before he learns the uses of the metals; and that he reduces the softer metals, and works in copper and bronze, long before he has acquired the mastery over iron and steel. In this way we speak of the ages of *stone*, *bronze*, and *iron*, the one preceding the other, and forming, as it were, a rude scale of time for the antiquarian and geologist. But while one nation may be working in iron, another more belated may be working in bronze, and a third, still more remote and savage, may be adhering to implements of wood and stone. To be of any use, this scale of stone, bronze, and iron must be applied to the same district; and when so applied, archæologists are now pretty well agreed that it marks with considerable certainty the various stages of relative antiquity. Of course, were implements of iron ever found along with remains of mammoth and mastodon, the scale would be utterly worthless; but when stone tools invariably accompany the older remains, and those of bronze and iron those of younger and younger date, then we feel assured from this concordance of the implement scale with that of the animal that we have hit upon a pretty exact method, so far as Europe at least is con-

cerned;* and it is by both of those modes that man's place in the geological record has been mainly determined.

It will be seen that in speaking of implements of stone, bronze, and iron, the geologist is trenching on the field of archæology, and the archæologist on that of geology. Both must, in fact, lend their aid in solving the question of man's antiquity; and whether it be by sepulchral barrows, by shell-mounds—the old feasting-stations of our northern ancestors—by pile-dwellings in lakes, or by flint implements in river-drifts, much the same kind of reasoning must be employed by both. A lake-dwelling, with implements of stone and bronze, may carry us no further back than the time of the Romans; while a tree-canoe, hollowed out by fire, and found under twelve or fourteen feet of river-silt, may take us thousands of years before Rome had a foundation. The inhabitants of Northern Europe may have lived on shell-fish, and been wrapt in skins, when the Pharaohs were clothed in fine linen and purple; but when we find stone implements associated with worked horns of the great Irish elk and reindeer, and with bones of the musk-ox, mammoth, and woolly-haired rhinoceros, and these in silts and drifts that indicate great physical changes in the geography of Europe, then we may rest assured that these monuments are *pre-historic* and of unknown antiquity. We have no indication in history that the mammoth, rhinoceros, or Irish deer were inhabitants of Southern and Western Europe; nothing either in history or tradition that points to the time when the reindeer and musk-ox roamed in the latitudes of France and England. It is true that natural events are rarely noticed in ancient history, and especially those of slow and gradual occurrence like the facts of geology; still

* Some archæologists divide the Stone Period into the *palæolithic* and *neolithic* stages—the former the age of rude stone implements, and when man shared the possession of Europe with the mammoth, the cave-bear, the the woolly-haired rhinoceros, and other extinct animals; and the latter the age of polished stone implements, and when man began to domesticate the dog, ox, horse, and other existing mammalia. In this way we have four stages of pre-historic time:—1. The Ancient Stone age; 2. The Newer Stone age; 3. The Bronze age; and, 4. The Iron age. For much interesting and well-condensed information on this topic, see *Lubbock's Pre-historic Times.*

it may be safely asserted that during the historic period none of the animals above referred to were inhabitants of the southern and western portions of our continent. Whatever the date of these stone implements, and their associated mammoth and rhinoceros remains, they clearly belong to pre-historic times; and the question is thus narrowed to the relative antiquities of certain events which occurred far beyond the reach of the oldest history and the remotest traditions.

In dealing with pre-historic monuments, we may adopt either the methods of the archæologist, who founds chiefly on the comparative rudeness and simplicity of the relics, or those of the geologist, who looks mainly to the superposition of the beds in which the relics occur, or those of the palæontologist, who argues from the specific differences of the flora and fauna; or we may adopt a mixed method, and reason from all that archæology, geology, and palæontology supply. Adopting this latter plan, we reason from the lake-silts, peat-mosses, and deltic deposits containing stone implements and tree-canoes, associated with the bones of extinct varieties of the horse and ox, back to similar deposits and cave-earths imbedding ruder implements and remains of the Irish deer, reindeer, and musk-ox, and from these again to deeper river gravels and brick-earths containing implements still simpler in fashion, and associated with the relics of mammoth and rhinoceros. Considerable changes in the physical geography of Europe must have taken place (as these silts and peat-growths imply) since the time of the primitive horse and long-fronted ox; still greater must have taken place since the reindeer and musk-ox found a suitable climate in the latitude of France and England; and greater still since the mammoth roamed in the pine forests and over the plains of the same regions. Admitting the changes, the question remains, How shall we estimate the lapse of time required for their fulfilment? If they are changes of a physical kind, we estimate according to the rate at which similar changes are taking place at the present day; if of a vital kind, by the rate at which extinctions and creations seem to have been effected in former epochs; and

if of a kind involving the progress of our own race, we know that civilisation in the long-run is only arrived at—even under the most favourable circumstances—by slow and gradual stages.

Guided by these methods, the pile-dwellings in lakes (the *pfahlbauten* of Switzerland and the *crannoges* of Ireland) carry us back to the earlier Celtic times, and may range from two to four thousand years, but clearly they are not of the vast antiquity some archæologists have imagined, and though pre-historic in Europe, may have been contemporary with historical events in Egypt and Western Asia. Estimated by the implement-scale, they belong alike to the ages of iron, bronze, and stone, and mark the long occupancy of South-western Europe by the same partially civilised but gradually improving race. As regards the shell-mounds (the *Kjökken-mödding* of Denmark) and the cave-dwellings of Belgium and France, they seem to indicate the presence of a pre-Celtic people, simpler in their mode of life, less civilised, and only acquainted with the use of implements in stone, wood, and bone. Smaller in stature than the Celt, round-headed, hunters and fishers, these pre-Celtic races never seem to have cultivated the soil, or to have settled down in fixed situations. Western Europe appears to have been their home before the Celts left the mountains of the East; and five or six thousand years ago may mark the date of their occupancy of the regions where now are found their shell-mounds, cave-dwellings, and kindred reliquiæ, Still earlier than these pre-Celts, Southern Europe to the shores of the Mediterranean, and Western Europe to the limits of the British Islands, seem to have been occupied by a ruder but perhaps kindred race—the fashioners of flint implements, and the contemporaries of the reindeer, the mammoth, and woolly rhinoceros. Reindeer, hairy elephants, and woolly rhinoceroses, in the latitudes of France and England, bespeak a severer climate than at present prevails, and under this boreal climate these rude races seem to have earned a scanty subsistence, by hunting and fishing along shore, by lake, and by river-side. And it is generally in such situations that their flint implements are found

associated with the bones and tusks and horns of these extinct mammalia. But these implements (like those of Abbeville, &c.) are often found at great depths, and at altitudes above the levels of existing rivers that prove the occurrence of great physical changes in these regions; and this, taken in conjunction with the extinction of the mammalia and the evident amelioration in climate, bespeaks a vast antiquity compared with the shell-mounds and pile-dwellings of the preceding races. A vast antiquity! but whether ten, twelve, or twenty thousand years, we have in the mean time no mode of precisely determining.

Physical changes proceed at rates too uncertain to constitute a scale of chronology, and we know too little of the law of vital development to found upon the duration and extinction of species. But if we may judge from existing operations, and if we may estimate from the specific changes in life now going on around us (and this with all the interfering influences imposed by man), then the time must be vast indeed since these primitive races were the inhabitants of Southern and Western Europe. We do not contend, like some, for thousands of centuries; but we argue for triple or quadruple the amount that has hitherto been assigned to human chronology. Let us look fairly at the facts: the river-drifts, cave-earths, and lake-silts are, no doubt, very ancient, but there is nothing connected therewith that may not (computing by existing operations) have been accomplished in ten or twelve thousand years. Again, the mammoth, woolly rhinoceros, cave-lion, cave-bear, and cave-hyena, are but species of existing genera; and so little do they vary in general character from those still living, that their appearance at the present day would excite no marvel. The whole aspects and surroundings of these extinct mammalia are in truth geologically recent; and when we further consider the fresh condition in which some of them occur in the ice-gravels of Siberia, we are compelled to withhold from them an unlimited antiquity. It is a sound maxim in palæontology, that the greater the divergence of any species from existing species, the greater its antiquity; and founding on this rule, the mammoth, mastodon, and their huge

congeners, cannot lay claim to the vast antiquity which many geologists have been so anxious to assign to them. Still, with all these facts and allowances, it must ever be remembered that the occurrence of hairy elephants and woolly rhinoceroses in Western Europe bespeaks a much colder climate than the present; and as changes in climate can only arise from great physical changes, great alterations must have taken place in the external conditions of our continent. Such changes are ever slow and gradual, and thus we are compelled to admit a high antiquity to the fashioners of these flint implements and their contemporaries, the mammoth and mastodon.

Indeed, the existence of a boreal climate necessitating shaggy coverings for the elephant and rhinoceros, would seem to carry us back to times immediately post-glacial—that is, to the time when the last traces of the glacial epoch were gradually being effaced by the advent of a more genial and equable climate. Were this the case, the appearance of man in Europe would be coeval with the earlier Post-tertiaries, and his antiquity much higher than the majority of geologists are yet prepared to admit. But his occurrence in Europe does not settle the question of his first appearance on the globe. On the contrary, the human race, in one or other of its varieties, may have existed for ages in Asia or Africa before it found its way to Western Europe, and, indeed, all that we know of language and ethnology seems to point to this conclusion. Before we can arrive at the absolute antiquity of man, or of his real place in the Geological Record, we must know more of the Asiatic and African Post-tertiaries, and more of the correlation of these to the Post-tertiary accumulations of Europe. We must also learn to deal with man as with other fossil genera, and instead of seeking for mere variations in skull and facial angle, we must be prepared to admit variations that amount to true specific distinctions. All animals in the history of the past, if they have existed long enough, break into varieties and species; and it will be a proof of man's comparative recentness, if we can discover no wider difference than mere varieties; but, on the contrary, it will be evidence of

his higher antiquity, if zoologists can show that any variation, past or existing, is so great as to entitle it to be ranked as a specific distinction. Man may be the sole species of a single genus, but in this particular zoologists have departed from the true Baconian method, and dealt with man as if he did not belong to the same category of vitality with which it is the duty of their science to deal; and not till they have learned to treat him from a natural-history point of view, can we hope to receive from them anything like truly philosophical opinion.

As the matter stands at present, we have evidence of man's occupancy in Europe during the formation of the earlier Post-tertiaries, and during the period when the reindeer, musk-ox, hairy elephant, and woolly rhinoceros roamed over its surface. The existence of these animals in Western Europe betokens a somewhat boreal climate, and in all likelihood man gradually took possession of the continent as the climate began to improve on the gradual recession of the glacial epoch. Arranging the Post-tertiary system, as has been proposed, into *Mammothian*, *Reindeer*, and *Bovine* stages, we find man occurring at least during a portion of the Mammothian stage, and thus bespeaking for him a vast and venerable antiquity—unexpressed in years, no doubt, but not on that account the less certain in its existence and duration. But while man's place in the geological record belongs to the earlier Post-tertiaries in Europe, older varieties of his race may have existed for untold ages in the regions of Asia and Africa, from which in all likelihood the European branches were descended.* On the advent of the

* "It is not under the hard conditions of the glacial epoch in Europe," says Dr Falconer, "that the earliest relics of the human race upon the globe are to be sought. Like the Esquimaux, Tehukche, and Samoyeds on the shores of the Icy Sea at the present day, man must have been then and there an emigrant placed under circumstances of rigorous and uncertain existence, unfavourable to the struggle of life and to the maintenance and spread of the species. It is rather in the great alluvial valleys of tropical or sub-tropical rivers, like the Ganges, the Irrawaddy, and the Nile, where we may expect to detect the vestiges of his earliest abode. It is there where the necessaries of life are produced by nature in the greatest variety and profusion, and obtained with the smallest effort—there where climate exacts the least protection against the vicissitudes of the weather—and there where the lower

glacial epoch over the latitudes of Europe, the pre-glacial animals seem to have receded to southern and more genial climates, and again on its departure they appear, in some of their species, to have returned to their old areas. It was during this post-glacial return that man seems to have made his first appearance in Europe—a fisher and hunter, forming rude stone implements, and, so far as geology has discovered, very low in the scale of civilisation. But while mammothian man was struggling along the river-banks of Europe for a scanty subsistence, other families of his race were in all probability—we may almost say were undoubtedly—enjoying a higher civilisation in the sub-tropical and higher tropical regions of Africa and Asia. Were these Asiatic races of the same variety of our species as the Abbeville flint-formers, or did they, though enjoying a higher degree of civilisation, belong to some older but inferior variety? Much, indeed, in the matter of man's antiquity will depend upon how this question is answered by subsequent discovery. If they belong to the same race, and there be no indication of any inferior species of our kind, in accordance with the great law of animal development, then, geologically speaking, man is of comparatively recent origin, and the question is narrowed to one or other of his existing varieties. Our own opinion is that, granting a law of development, the higher animals pass through fewer intermediate stages than the lower, and that, in man's case, species more closely related to the quadrumana are scarcely to be expected. But while this may be true, it is equally certain that if there be any truth in geological development at all, the higher varieties must be more recent than the lower; and thus the white variety of man more recent than either the Red Indian, the Negro, the Malay, or the Mongol. And it is equally certain, according to any law of development, that the older and lower varieties must first pass away—a fact in wonderful

animals which approach man nearest now exist, and where fossil remains turn up in greatest variety and abundance. The earliest date to which man has as yet been traced back in Europe, is probably but as yesterday in comparison with the epoch at which he made his appearance in more favoured regions."—*On the asserted occurrence of human bones in the ancient fluviatile deposits of the Nile and Ganges—Quarterly Journal of Geology*, 1865.

accordance with the gradual disappearance of the coloured varieties before the spread of the white variety of our kind. Here, then, we have a twofold argument that may avail us in our researches, viz., the earlier appearance, and, conversely, the earlier disappearance of the lower varieties of a species; and applying this to Man, the coloured varieties, which are evidently inferior (whatever may be said to the contrary), must have long preceded the white, just as now they are passing away before it.

In this way we carry the antiquity of man—high as it may be in Europe—to a still higher antiquity in the other continents of the Old World, and which must be geologically investigated before any definite conclusion can be arrived at, either as regards antiquity or developmental descent.* The European men of the Bovine and Reindeer periods evidently belonged to the white or Caucasian variety, but we have no certain evidence whether the Abbeville flint-fashioners were of Caucasian, Mongolian, or other variety. To whatever variety they belonged, they were clearly of a date immediately post-glacial, though, could it be shown by craniology that they were of other type than the Caucasian, it would, in our opinion, be further proof of their high antiquity. If we are to pursue the subject of man's antiquity in Africa or Asia, this question of type must constitute one of the main elements of determination, for it would be outraging every principle in science to apply the test of variation and development to the other orders of life, and shrink from applying it in the solitary instance of man. Where we can prove by archæological means a high antiquity for man, let us adopt them; where we can show the same result by geological methods, let us not neglect them; but at the same time let us also value those palæontological doctrines of progression and development which have thrown so much light on the order and connection of vitality in general. If there be such a law of progression, man must

* Since the above was written, we observe that implements of quartzite have been discovered in the lateritic formation of Madras by Messrs Foote and King of the Indian Geological Survey, thus opening the way to this new and much desiderated line of evidence.

be as amenable to it as the rest of creation, and whatever variation occurs in his race must be taken, along with other elements, as a measure of time and duration. We are aware that many geologists shrink from the test of variation, and feel an uneasy tenderness whenever the question of man's descent becomes involved in their researches and speculations. Truth, however, will never be attained by such weakness. In science as in morals error becomes only more deeply rooted, and bigotry more emboldened, the longer that honest conviction hesitates, or gives to its beliefs a timorous and uncertain utterance.

Such are some of the reasonings that suggest themselves in reviewing the question of "Man's Place in the Geological Record." In the first place, let it be treated without bias or predilection, as a matter of natural history and geology. In the second place, let us avail ourselves of all the evidence that history, archæology, geology, and palæontology can supply. And in the third place, let us, as true geologists, be wary in assigning dates in years and centuries, while the whole superstructure of our science is founded on a relative and not upon an absolute chronology. Guided by these methods, it would appear that man has been an inhabitant of Southern and Western Europe from a time immediately succeeding the close of the glacial epoch, and that in these regions his antiquity dates, if not from the very earliest, at least from the earlier of the Post-tertiary formations. How long ago this may have been in years and centuries, there is no condescension on the part of legitimate geology; but clearly it is far, very far, beyond the limits of the ordinarily received chronology of the human race. But ancient as this may be, the implement-bearing gravels, the cave-earths, the peat-mosses, shell-mounds, and lake-dwellings of Europe cannot be taken as a measure of antiquity for Asia, from which, as everything tends to show, the first races of Europe were derived by the ordinary means of natural dispersion and selection. And even were the first appearance of the White or Caucasian race geologically determined in Asia, the first appearance of the coloured varieties (Mongol, Negro,

Malay, &c.), each in its own proper head-quarter, would still remain a problem of antecedent date, requiring similar methods of research, and similar processes of solution. In this way, and on the fair presumption of the coloured and inferior being the older varieties, the antiquity of man as a species mounts still higher and higher, and the course of discovery may yet compel us—nay, will almost to a certainty compel us—to assign to him an origin coeval with the very dawn of what we are in the habit of regarding as the Quaternary system, if not, indeed, with the close of the later Tertiaries, and just when the more gigantic fauna of that epoch was passing away from the warmer zones of Asia, Africa, and America.

A vote of thanks, moved by Mr William Turner, M.B., was given to Mr Page for his learned, suggestive, and interesting Address, and for his valuable services as President of the Society.

The Rev. James Brodie, of Monimail, concurred in the vote of thanks now passed, he considered the address of his old acquaintance, Mr David Page, as a very able one, and admired the clear and temperate manner in which he had expressed himself. At the same time, he must say he dissented altogether from the conclusion to which he had arrived.

He entered on the consideration of this question free from all bias. He believed the Bible to be unquestionably the Word of God, but he regarded the record in Genesis as having reference only to creatures at present existing. The covering of the earth with " darkness and the deep" implied a deluge altogether anomalous and miraculous. The creation which followed was in a great measure a reconstruction of beings formerly existing. In short, there was nothing in Scripture to prevent him believing that races of men had inhabited the earth previous to the creation of Adam; but he had never seen any facts adduced that afforded the slightest proof of the existence of pre-Adamite man.

He objected to Mr Page's conclusions on grounds purely

scientific. That man existed along with the mammoth and rhinoceros, and that these animals are now extinct, does not prove that a long period must have elapsed in order to allow them to perish by a gradual decay; it rather leads to the inference that they were destroyed by the weapons of man. That rude implements of flint were first employed, and afterwards implements of bone, horn, or bronze, of a more artificial construction, is to be ascribed to the fact that spears pointed with flint were the most effective weapons that could be used against the larger mammalia, in the same way as the spears of the negroes are used in killing the elephants of Africa; and that, when the larger game became scarce, weapons of a lighter but more artificial construction were required in attacking the smaller but swifter animals. Improvement in manufactures, moreover, does not necessarily imply a long period to allow the aboriginal tribes to perfect their fabrics, but is rather to be ascribed to the coming in of more cultivated races, who may possibly have exterminated the former inhabitants. The change from a boreal to a temperate climate must be ascribed to some physical change on the surface of the globe. These changes are sometimes slow, but more generally they are rapid; and a geological change altering the currents of the Atlantic might in a single season bring back on Britain all the rigours of the glacial epoch. He could not, therefore, agree in Mr Page's conclusions.

Wednesday, December 27, 1865.—WILLIAM TURNER, M.B., President, in the Chair.

The following Gentlemen were elected Office-Bearers for the Session:—

Presidents.—William Turner, M.B.; Thomas Strethill Wright, M.D.; Stevenson Macadam, Ph.D.

Council.—Alexander Bryson, Esq.; James M'Bain, M.D.; Ramsay H. Traquair, M.D.; David Page, Esq.; Professor John Duns, D.D.; William Rhind, Esq.

Secretary.—John Alexander Smith, M.D.

Treasurer.—George Logan, Esq., W.S.

Assistant-Secretary.—James Boyd Davies, Esq.

Librarian.—Andrew Taylor, Esq.

Library Committee.—Thomas Robertson, Esq., Andrew Taylor, Esq.

The following Gentlemen were elected Foreign Members of the Society:—

Sr. Durchlaucht Fürst Colloredo-Mannsfeld, the President, Dr Theodor Kotschy, the Vice-President, and Dr Georg Ritter von Frauenfeld, the Secretary, of the Zoological and Botanical Society of Vienna.

The following Donations to the Library were laid on the Table, and thanks voted to the Donors:—

1. Proceedings of the Literary and Philosophical Society of Liverpool, Session 1863–64, No. 18.—From the Society. 2. On the Food of Man in relation to his Useful Work, by Professor Lyon Playfair, C.B. —From the Author. 3. Journal of Linnean Society, vol. ix. No. 35.—From the Society. 4. Proceedings of the Royal Society, Nos. 72, 73, and 77, Vol. XIV.—From the Society. 5. Canadian Journal, Nos. 54, 56, 57, 58, and 59.—From the Canadian Institute, Toronto. 6. Proceedings of the Geologists' Association, 1864–65.—From the Association. 7. Declaration of Students of the Natural and Physical Sciences.—From the Authors. 8. Transactions of the Botanical Society of Edinburgh, Vol. VIII., Part 2.—From the Society. 9. Notes on Spa, &c., by Thomas Cutler, M.D.—From the Author. 10. Transactions of the Geological Society of Glasgow, Part 1, Vol. II.—From the Society.

The following Communications were read:—

I William Turner, M.B., exhibited two specimens of the *Lerneopoda elongata* attached to the eyes of the Greenland Shark (*Scymnus borealis*).

The specimens of this curious parasitic animal had been recently procured for him in Greenland by his pupil, Mr R. Smith.

II. (1.) Dr John Alex. Smith exhibited perfect specimens of the new Ganoid Fish, *Erpetoichthys Calabaricus*, from Old Calabar.

At the meeting of the Society in March last Dr Smith exhibited two specimens of a new ganoid fish which had been sent to him from Old Calabar by the Rev. Alexander Robb. They were allied to the genus *Polypterus*.

From the difference in shape of these Calabar fish—their bodies being more cylindrical and elongated in proportion to their breadth (having, indeed, quite a serpent-like aspect), the fins being small in size, and the ventral fins apparently absent, and as they also wanted one of the opercular plates that existed in Polypterus—Dr Smith

considered he was justified in constituting them a distinct genus, to which he gave the name of *Erpetoichthys** or serpent-fish. As both the specimens, however, were imperfect, he could not at that time complete his description of the species, which, from the locality where they were found, he named the *E. Calabaricus.*

He was now, however, able to exhibit perfect specimens of this curious fish, which he had just received from the Rev. Alexander Robb, and was glad to say his previous views of its generic differences were confirmed, and the fish showed a total absence of ventral fins.

The largest specimen measured 12½ inches in length by rather more than half an inch in breadth, and the head measured 1 inch in length.

(2.) Dr John Alex. Smith exhibited several of our rarer British Birds —*Grus cinerea* (Common Crane), *Lanius excubitor* (Great Grey Shrike), *Picus major* (Great Spotted Woodpecker), *Thalassidroma pelagica* (Stormy Petrel), *Bombycilla garrula* (Bohemian Waxwing), *Astur palumbarius* (Goshawk)—and Birds showing accidental varieties in plumage.

Dr Smith said he had to call the attention of the members to the recent occurrence of several birds which were rare or occasional visitors to this country; and also to others, showing varieties from the ordinary character of their plumage. He would mention the birds of which he had notes, nearly in the order in which they had been captured.

1. *Grus cinerea* (Flem.), The Common Crane.

This beautiful specimen was shot at Boness, in the island of Unst, Shetland, in the beginning of July last, and has been presented by Thomas Edmonston, Esq., to our Museum of Science and Art. It is now a very rare visitor to Britain, although it appears to have been seen more frequently in ancient times.

2. *Lanius excubitor* (Penn.), The Great Grey Shrike.

Of this species no less than four specimens have been recently noticed—one having been shot near Alloa in

* The name of the fish has since been changed to *Calamoichthys Calabaricus* (see detailed description in Trans. Roy. Soc. Edin. vol. xxiv. 1866).

October; another on the 16th of October, at Fenton Barns, East-Lothian; a third by Sir George Leith, in Dumbartonshire, in the beginning of December; and the last was shot near Broughton, in Peeblesshire, on the 2d of December. The stomach of one of these birds contained a field mouse, and the remains of a small bird were found in the stomach of another specimen.

3. *Picus major* (Penn.), Great Spotted Woodpecker.

This specimen was killed at Ninewar, East-Lothian, on the 20th of October. It is considered to be one of our rarer permanent residents, although some naturalists believe we occasionally have an addition to the number of these birds in early winter, from their migrations in Northern Europe.

4. *Thalassidroma pelagica* (Delby), Stormy Petrel.

On the same date, the 20th October, a Stormy Petrel was caught, in a very weak state, near Liberton, close by Edinburgh.

5. *Bombycilla garrula* (Flem.), The Bohemian Waxwing.

This bird was shot at Archerfield, East-Lothian, on the 21st November. Its stomach was found to be filled with the fruit of the hawthorn. One was shot at the same place forty years before.

6. *Astur palumbarius* (Selby), The Goshawk.

The specimen exhibited was a young male, and was shot near Tynehead, Mid-Lothian, on the 13th December. This fine bird, now one of our rarest hawks, was formerly much used in falconry, and flown at the larger game. It measured 1 foot 10 inches in length from beak to point of tail, and 3 feet 4 inches across the extended wings; the length of wing from the flexure to the point of the fourth, the longest primary, was 13 inches. The closed wings are comparatively short, reaching to about half the length of the tail. The upper parts are of a dark rich reddish-brown colour, some of the feathers being edged with lighter; the head and nape with feathers edged with light reddish brown. The tail is 11 inches in length, with alternate bands of dark brown and light greyish-brown—the terminal being of light greyish-

brown. The bill was dark blue, with a black point, and festooned, the cere greenish-yellow, and the eyes orange; chin nearly white, with longitudinal lines of dark brown; breast and belly light reddish or brownish white, with longitudinal blotches of dark brown, becoming lines of dark brown on the thighs; under wing coverts light reddish-brown, with long-shaped blotches of dark brown; inside of primaries greyish-white, with transverse bars of brown. Legs—tibia 4 inches long; tarsus (yellow), 3 inches; middle toe and claw nearly 2¾ inches in length; claws dark blue or black; the tarsus is feathered at the top, and below is covered with transverse scutellæ in front and behind, with small angular scales between; the middle toe is slightly longer than the lateral toes, which are nearly equal in length; the claws of the first and second toes are the largest.

The following birds exhibited, showed accidental peculiarities in their plumage:—

Passer domesticus (Common Sparrow), nearly pure white, shot near Peebles in the beginning of October.

Varieties of the *Perdix cinerea* (Common Partridge)—one spotted all over with white feathers, shot near Duddingston on the 20th of October; another, with nearly pure white primaries of the wings, shot at Mellerstain, Berwickshire, by Lord Binning, in October; and also one showing the horse-shoe mark on the breast, of a pure white colour, shot by the same gentleman in the beginning of December. A peculiarly light-coloured variety of the partridge was also examined, shot by A. Burn Murdoch, Esq., at Gartincaber, in October.

A very dark red variety of the *Lagopus scoticus* (Red Grouse), showing various pure white feathers about the head and the abdomen, the property of Cluny Macpherson, was shot in Inverness-shire, in the beginning of December. Dr Smith was indebted to Mr Sanderson, bird-stuffer, George Street, for exhibiting the Goshawk, and to Mr Small, bird-stuffer, George Street, for various specimens exhibited.

(3.) Dr Smith said he might also notice the recent capture of a fine specimen of the *Labrus bergylta* (Ballan Wrasse), near Cellardykes.

It is considered of rather rare occurrence in the Firth of Forth, though common elsewhere. It was kindly sent to Dr Smith by Mr Muirhead, Queen Street, as a rarity, and was now being preserved for our important National Museum of Science and Art. The fish was 18¼ inches long, by 13 inches in circumference at the root of the ventral fins, and weighed rather more than 3¾ lbs.

III. Mr W. R. M'Nab *exhibited several species of* Coleoptera, *which had been recently collected in Egypt by Professor Piazzi Smyth.*

Among the specimens of beetles exhibited was one from the interior of the Great Pyramid. It belongs to the *Heteromera*, and is apparently new, but has not yet been sufficiently examined. The collection included the *Ateuchus sacer*, the Sacred Beetle of Egypt; several *Heteromera*, a *Graphipterus variegatus*, Fab., and others of interest.

IV. Mr Adam White *exhibited two boxes of interesting* Lepidopterous *and* Hymenopterous *insects.*

Amongst the former the glorious resplendent blue of a South American butterfly, *Morpho cypris*, was very conspicuous. The curious Driver-ant of West Africa, the Mason-bee, Mud-dauber, and other interesting ants, wasps, and bees, were pointed out, which had histories and stories that would fill volumes. The strange diversity in size and appearance of the sexes of a species of *Dorylus* and *Thynnus* was alluded to.

Wednesday, January 24, 1866.—William Turner, M.B., President, in the Chair.

The following Donations to the Library were laid on the Table, and thanks voted to the Donors:—

1. (1.) Transactions of the Royal Irish Academy, Vol. XXIV.; Science, Parts 4–6; Antiquities, Parts 2, 3, and 4; Polite Literature, Part 2. (2.) Proceedings of the Royal Irish Academy, Vols. VII.

and VIII., and Part 1, Vol. IX.—From the Academy. 2. Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt, 1865, XV Band. Nro. 3, Juli, August, September.—From the I. R. Geological Institute of Vienna. 3. Natuurkundig Tijdschrift voor Nederlandsch Indie, uitgegeven door de Knoninklijke Natuurkundige vereeniging in Nederlandsch Indie, Deel XXVI., Zesde Serie Deel I., Aflevering 3-6; Deel XXVII., Zesde Serie Deel II.; Batavia, H. M. Vandorp's Gravenhage; Martinus Nyhoff, 1864.

The following Communications were read:—

I. *An Inquiry into the Action of the Natural Agencies by which Level Terraces are produced, and into the proofs thereby afforded that the elevation of the central parts of Scotland must have been the effect of a sudden upheaval.* By the Rev. JAMES BRODIE, Monimail.

In the central districts of Scotland, both on the east coast and on the west, littoral deposits are found, forming level terraces or beaches, and containing marine shells of existing species. Two terraces have more especially attracted attention. The lower is from 5 to 20 feet above ordinary high-water mark; the upper is from 15 to 20, or even 25 feet above the lower. The lower terrace varies in breadth from a few yards to several miles; the upper is generally much more limited in its extent. The accuracy of these statements is very generally acknowledged. That these appearances indicate the action of water all are ready to allow; but opinions differ widely as to the nature of that action, and as to the inferences to be drawn from these appearances. The idea generally entertained seems to be that these terraces were formed beneath the water, that they have been raised to their present position by a slow and gradual process of elevation, and that we must therefore ascribe to the deposits found in them a very great antiquity. In opposition to these views, we are prepared to maintain that the elevation of the central part of Scotland has not been the effect of a gradual rise of the land, but of a sudden upheaval, and consequently that the calculations which rest on the hypothesis of a gradual rise should be set aside.

Formation of Level Terraces.

In order to understand the subject aright, we must direct our attention to the manner in which the agency of the

waves is exerted in forming these level terraces. With this purpose in view, let us trace the course of a pebble lying on the beach. When the wave strikes against the shore, the pebble is hurried upwards towards the land; but when the billow retreats, it is carried back. This process is repeated again and again. If the retreating waves prove the stronger, the stone is carried farther and farther back, till at last it reaches a depth where the agitation of the surface can no longer disturb its repose. Other pieces of stone or shell are in like manner brought down and laid beside the first, and others, again, are carried still farther into the deep, rolling over the former ones, and resting behind them. In this manner a terrace or level bed is formed beneath the water. This deposition of sedimentary matter under the water is not, however, the only level terrace that is produced by the action of the waves. Every observer who has walked along the shore must have remarked that, while many substances swept backwards and forwards by the wave are gradually carried into the deep, others are thrown up on the beach, and there left dry. The material thus cast up, of whatever kind it may be, does not find a resting-place till it has been carried up beyond the reach of the highest flood. When the land, to use a common expression, is gaining on the sea, and the quantity of debris brought along by the tide is large, the gravel, sea-weed, and shells thus drawn up form a terrace, which varies in height according to the strength of the waves. A similar agency produces level terraces on the sides of lakes, and, on a smaller scale, on the sides of artificial ponds and reservoirs. When the banks are steep and of friable material, the billows raised by the wind wash down a portion of the bank, and form a general deposit under the water, like the lower terrace produced by the retreating waves of the sea. On the other hand, when the banks slope gently down to the water's edge, the floating mud, carried along by the waves, settles down among the reeds and rushes that usually grow in such situations, and, mingling with the decaying vegetation, forms a level deposit which corresponds in some measure to the terraces thrown up by the advancing billows

of the ocean. There is one circumstance in reference to the formation of these terraces on the borders of lakes which does not seem to be generally taken into consideration; that is, the effect produced by floating ice. Water washing against a friable bank will no doubt wear it down, and in course of time will form a terrace; but the operation will be much more speedily effected if it bear on its surface masses of ice which are carried by the waves against the banks, and act like the battering-rams of the ancient warriors. The accounts that we read of the devastations sometimes caused by floating ice brought down by the rivers in America amply confirm these remarks. It seems to us of great importance, in forming any hypothesis in regard to level terraces, raised beaches, sea-margins, or whatever other name may be given to them, to remember that they are of two kinds. One is formed below the surface of the water, and the other above it; one is produced by the retreating, and the other by the advancing billow. The deposits left by rivers are altogether different in their origin and character from those which we find on the banks of lakes and on the shores of the sea. So long as the river is confined in a narrow channel, the gravel and mud which it brings down are swept along together by the current. When the channel becomes wider, the sand and gravel are left behind, and form a bed, which has always a distinct downward slope according to the course of the stream. When the channel is still farther enlarged, the current becomes slower, the mud is deposited, and forms deltas and valleys, like those of the Mississippi and Ganges, with a surface nearly horizontal.

Character and Appearance of these Terraces.

The terraces found on the sides of lakes are regular and horizontal, making allowance, of course, for those places where the waves are particularly high; but this is not the case in regard to the deposits left by the ocean. The upper terraces, formed by the advancing billow above ordinary high-water mark, sometimes exhibit a very remarkable horizontality of outline. When the material thrown up consists of shingle or gravel of such weight as to resist the action of

the wind, the level can be easily traced. The shingle either remains altogether bare, or is covered with only a few inches of sandy soil. When, along with the gravel, there is a small quantity of sand, not sufficient to bury beneath it the grass and other plants that grow in such situations, we find, it may be, several feet of soil covering the shingle and forming a surface, which may be termed level, though the uniformity be broken by a number of small irregularities. When the quantity of sand is great, it is formed by the force of the wind into hillocks of considerable height, and is sometimes spread over a large extent of ground. Tradition, for example, says that the sand thrown up by the sea in one terrible storm on the coast of Aberdeenshire, was so great that, when afterwards drifted by the wind, it covered over a whole parish in the neighbourhood of Slains. A great proportion of what are called *downs* in England and *links* in Scotland seem to have been formed in this manner. They are terraces thrown up by the advancing billow, and afterwards covered by a varying depth of sand. In estuaries the material thrown up consists principally of mud, which hardens when dry, and is not so readily blown about by the wind. After it has been thrown up it settles down upon the roots of whatever plants may be growing on the shore, and promotes their increase. By this means it is evenly spread over the surface, and forms the rich alluvial soil which we sometimes find on the plains that border the mouths of rivers. The lower terraces formed under the water by the retreating wave do not in general possess a horizontality of surface so distinctly marked as that which we find in those that are formed above high-water mark by the advancing billow. There is no doubt that the agency of the waves, if it acted alone, would produce a level platform below the water, as well as one above it; but wherever there are currents, the material, carried into the deeper water by the retreating wave, is swept before them, and thrown up into banks of very irregular height. In lakes and seas, where there is neither stream nor tide, and in landlocked gulfs, where the movements usually found in the ocean have little influence, a level terrace under the water

may probably be discovered. But on the British coasts instances of such terraces seem to be very rare. The author of these remarks was at one time led to suppose that horizontal surfaces might as frequently be produced under water as above it. On further investigation, however, he sees that he was mistaken. The soundings given in the charts do not indicate in any place a regular level terrace below low-water mark; and he would refer to the experience and observation of the members of the Royal Physical Society whether they can point out any instances of level terraces formed under the water in places that are affected by the tide. The inquiry possesses considerable interest for those who engage in geological speculations. If, on full examination, it shall be found that, while level terraces above high-water mark are in constant process of formation, there are very few, if any, now forming under low-water mark, we are naturally led to conclude that the ancient sea-margins found along our coasts were not deposited, as some seem to imagine, at the bottom of the sea, but were thrown up on the shore, in the same manner as those that we now see forming there. As a further proof that the terrace or level platform which we so frequently find on the sea-shore, some 10 or 15 feet above ordinary high-water mark, has been thrown up by the advancing billow, and has not been formed, as some suppose, beneath the water, we may refer to the fact, that the shells found in these terraces do not lie in the position which they must have occupied in their native bed, but are heaped together in a confused mass; while no limpet or shell of similar nature is found adhering to the rocks that rise above the level of the terrace.

Height of Terrace in Relation to the Ordinary Level of the Sea.

When the terrace is formed by the advancing wave, its elevation above ordinary flood-mark must depend on the force with which the billow is driven against the beach. On those parts of the western coast of Scotland, for instance, which are exposed to the full swell of the Atlantic, they will rise much higher than on our eastern shores, and any

deposit that may there be thrown up must be proportionably higher. We further find that, in creeks and estuaries, which gradually become narrower as they run up into the land, the tide, especially in storms, rises higher and higher as the channel becomes more and more confined. The Bay of Fundy, on the coast of America, where the tide rises and falls fully 40 feet, is an illustration of this remark. The Solway Firth, with its peculiarly rapid tide, may be referred to as another. The ordinary height of the terrace on those parts of the coast which are not exposed to any great violence of tempest, seems to be from 5 to 15 feet above high-water mark, which is the height to which a full tide wave will be driven by a storm. At the head of estuaries, it appears formerly to have been some 5 to 10 feet higher, while a still greater elevation may be expected in those creeks and inlets which are exposed to the billows of the Western Ocean.

Inferences to be drawn from these Investigations.

The inferences which we draw from these investigations into the action of the natural agencies by which level terraces are produced, may be stated in three propositions:—1. While these terraces were in course of formation, the relative height of the land and water must have remained unchanged. So long as the high-water mark continues stationary, whatever addition may year by year be made to the shore, the height to which the mud or shingle is carried will remain the same; but if, year by year, the land rises, and consequently the high-water mark descends, so, in like manner, will the comparative height to which the mud or shingle is carried be diminished. A continuous upheaval of any portion of the sea-shore must therefore produce, not a level terrace, but a uniformly sloping bank. 2. Similar arguments serve to show that if the land, after remaining stationary for a time, during which the level terrace has been formed, begins continuously to rise, the terrace will not terminate abruptly, but in a gentle, uniform descent. 3. If any portion of the earth's surface has been raised above its former level, the manner in which the elevations

took place may be determined by the character of its shores. If the shore exhibit an unbroken, shelving descent, there is reason to conclude that the movement has been uniform and continuous. If the land is bordered by level terraces, ending in abrupt descents, then times of rest have been followed by sudden upheavals.

Elevation of the Scottish Coasts.

In the middle districts of Scotland, more especially in the estuaries of the Forth and Tay, we find plains of considerable extent. The soil is a rich alluvium, evidently formed of the mud brought down from the higher grounds. In the parts nearest the sea they are raised only a few feet above the water, and are liable to be flooded at spring tides. In the places that are farthest from the sea, the level of the soil is from 10 to 20 feet above the ordinary high-water mark. The uniform horizontality of the surface, especially in the lower parts, is very remarkable. The appearance which they present seems to be exactly such as would be produced by the agencies we have been examining, if we were to suppose the sea and land to have remained at their present level through a lengthened series of years. Various circumstances, however, show that they must have been raised to their present position by the action of internal forces. The skeleton of a whale was found at Airthrie, near Stirling, entire, and in good preservation, a few feet below the present surface of the soil, and about 20 feet above high-water mark. If that animal had been cast ashore and left on the bank exposed to the influence of the atmosphere and to the action of the waves, the skeleton must have separated into pieces, and the bones must have been scattered and broken. The circumstance of its having been found entire can only be explained on the supposition that it had sunk in deep water, and been embedded in mud, while the bones, and the ligaments binding them together, were still undecayed. If, therefore, when it perished, it sank in deep water, and if, when disinterred, it was found nearly 20 feet above the present high-water mark, the inference is plain—the land must have been raised. Some discoveries that

have been made on the banks of the Clyde still more decidedly confirm this conclusion. In some excavations in the neighbourhood of Glasgow the workmen came on a number of ancient vessels, generally made out of a single tree. They were found at different depths, and when first exposed were quite entire. They had evidently owed their preservation to their having been sunk completely under the water. If they had not been protected from the weather by the sediment in which they were embedded, they would very speedily have rotted away, and left no trace behind. We therefore conclude that the *carse* lands of Scotland must be regarded as bottoms of the estuaries of a former time, raised, we may presume, some feet above the present high-water mark. In that position they have been subjected to the horizontalising effects of the high-water billows. The upper parts have thus received that level surface which they now exhibit. The lower portions are the deposits of more ancient times. The plains of sand, or sandy soil, which we term links, are found on the shores of the open sea. Wherever debris has been thrown up by the tide, and land has been gained from the sea, the ground thus formed has exactly that elevation above the level of the ocean which we would expect to result from the action of the advancing billow. Where the beach is open, the level surface is from 5 to 15 feet above ordinary high-water mark, the height varying according to the force of the wave. In general they are covered by a quantity of drifted sand; their surface is consequently irregular; but after allowing for the irregularities thus produced, their elevation is exactly such as we might have expected to find in a high-water terrace produced by the action of the sea at its present level. We do not find in these links any evidence of an elevation of the land by internal forces; but that elevation, proved by the discoveries to which we before referred to have occurred, must have tended very largely to increase their extent. The other range of terraces, which are usually described as from 20 to 30 feet above those to which we have been referring, are comparatively of small extent, which suggests the idea of a shorter time having been occu-

pied in their formation. In every case, we believe, they terminate abruptly; that is, their sides have just such an indication towards the sea as we find in the high-water terraces of modern formation. They seem to have been thrown up by the advancing wave in the period that immediately preceded the last elevation of the land.

The Upheaval of the Scottish Coast has been sudden.

Many maintain that it has been gradual. They direct our attention to the coasts of Sweden, and tell us that there we find evidence of a gradual rise, and that we should therefore conclude that such has also been the case in Scotland. To this we reply, that if the land be slowly and gradually rising in Sweden, it has been suddenly elevated in many other quarters of the globe. We go farther, and affirm that sudden upheaval is the rule, if rule may be spoken of in such a case, and that gradual elevation is the exception. Again, we ask, "How do we know that the land is gradually rising in Sweden?" It is because channels with rocky bottoms are becoming shallower, and because rocks that were formerly under the water are now seen above it. By a parity of reasoning, we conclude that the land in Scotland is *not* rising, because there are no rocks that were formerly known to be under the water that now rise above it, and there is no instance of the height to which the water rises in any flood-gate or harbour having become less than it was in the days of our fathers. It has again been argued, that in some places where the water was formerly deep it has become shallow. That, however, is no decisive proof of a general elevation of the land. It may be the natural effect of those changes that are continually taking place in tidal currents. If, in the bay opposite the mouth of the Esk, we find land where there formerly was sea, between Leith and Newhaven we have sea where formerly there was land. Neither history nor tradition affords the slightest countenance to the idea of a gradual and uniform rise. . . . . . The appearance of our *links* and *carses* is precisely such as we might expect to result from the continued action of the billows at the present

level of the ocean. We therefore conclude that the elevation of the central parts of Scotland has not been gradual but sudden; and that the argument brought forward in order to prove the great antiquity of the fossils found in our ancient sea-margins rests on a conjecture which the facts that have been observed distinctly disprove.

A discussion followed the reading of this paper, in which Mr Alexander Bryson, Mr David Page, Professor M'Donald, Dr M'Bain, and Mr Rhind took part; and on the motion of the President, a vote of thanks was unanimously given to the Rev. Mr Brodie for his interesting and suggestive communication.

II. *Note of the Occurrence of the Death's Head Moth in Shetland, &c.* By ADAM WHITE, Esq.

Mr White exhibited a specimen of the Death's Head Moth, sent him from Voe, in Shetland, by Mr Adie of that place. This insect had apparently been abundant last year all over Britain, and had occurred even as far north as Shetland. He also exhibited a specimen of the *Mergulus alle*, the little Arctic Rotche or Auk, found after a storm at Prestonpans, and belonging to Mr George Hay of Prestonpans. Mr White exhibited some early flowers, and also a group of beautifully-executed artificial flowers from Paris, kindly lent him by a perfumer in George Street.

III. (1.) *Specimens of Weaver Bird's Pensile Nests, &c., recently sent from Old Calabar by the* Rev. ALEXANDER ROBB, *were exhibited by* Dr JOHN ALEX. SMITH.

The nests were somewhat of the shape of a chemist's large retort, the body of the retort being, however, a little more bent over the neck than usual; the specimens varied in size and in their state of completeness, some being apparently only partially finished. The largest nests measured some seven inches across the body of the nest, by six or eight inches in height; the neck or passage to the nest was about two feet in length, and increased from four to five

inches in diameter across the neck, next the nest, to five or six inches across its trumpet-like mouth or further extremity. Mr Robb informed Dr Smith that these nests were generally hung from the branches of palm trees, the leaflets of the palm being worked round the neck of the nest, and frequently over water, so that the bird could safely enter from below the pendant opening of its long passage, and creep up to the nest above, and no monkey or snake could manage to get at the nest. Dr Smith believed the bird to belong to the family of the Weaver birds, but the species he was not yet cognisant of. He had, however, written to Mr Robb to send home, if possible, specimens of the builder of the nest, so that there might be no doubt of the species. The nest was beautifully and strongly made of the interlaced stalks apparently of grasses.

Professor Balfour, in reply to inquiries by Dr Smith, stated that the plants forming the nest belong to the monocotyledonous class, and were probably glumiferous; the venation and stomata indicate this.

Mr Hewan informed Dr Smith of the existence of another curious Calabar pensile nest, which was frequently built in the palm leaves; the bird apparently stripped the leaflets of the palm from their midribs, and plaited them into the nest, the naked midribs supporting the finished fabric. Dr Smith hoped at some future time to be able also to exhibit to the Society specimens of this very curious nest.

(2.) *A Specimen of the* Lanius excubitor (*the Great Grey Shrike*), *shot near Roslin, was exhibited by* Dr John Alex. Smith.

Dr Smith was indebted to J. W. W. Wedderburn, Esq. of Rosebank, Roslin, for being able to exhibit the fine adult male specimen of the *Lanius excubitor*, the Great Grey Shrike, now on the table. It was shot by him in the end of December last, and he informed Dr Smith that he had also seen another specimen of the bird in the same neighbourhood a few days after; not having his gun, this bird escaped. The specimen exhibited, Dr Smith said, had in its stomach a gold-crested wren, which was entire, with the exception of the head being crushed—the usual manner in which the shrike

kills its prey. The bird is said frequently to impale its prey on a thorn, and pull it to pieces as it devours it. In this case, however, the small gold crest was quite entire, the legs and wings being perfect, the larger feathers even not being removed. From the feathers and other parts of the bird being swallowed, it is plain that the shrike must cast up the indigestible parts of its food in pellets, like the owls, hawks, and many other birds.

No less than five or six of these shrikes have been noticed this winter—a very unusual number; several of these instances were referred to at the last meeting of the Society.

IV. *Note of a Bone of the* Bos primigenius, *found near Dunse, Berwickshire.* By George Logan, Esq.

Mr Logan stated that the bone of the *Bos primigenius* exhibited was found in the course of operations for deepening the river Leet, near Swinton Mill, Berwickshire. It was found in the alluvium, a little below the surface.

Mr Wm. Turner said he had examined the bone, and believed it to be part of the right humerus of a young animal, and the locality was apparently a new one for this species of ancient ox.

V. *Notes on the Discovery, by the* Rev. Alexander Robb, *in* 1863, *of an Insect feeding on the Esere, the Ordeal or Poison Bean of Old Calabar.* By John Alex. Smith, M.D.

Dr Smith read extracts from a letter, dated Old Calabar, 30th August 1865, which he had recently received from the Rev. Alex. Robb, mentioning, among other things, that a friend had sent him a London newspaper containing the following statement:—

"It is said that a species of Toucan lives upon the fruit which produces strychnia, but an equally strange announcement has just been made by Dr Fraser with regard to one of the Lepidoptera. It has been found by this well-known physician that the larva of a species of moth lives upon the Calabar Bean, a drug now much in vogue among ophthalmic surgeons, and whose action on the eye causes rapid diminution in the size of the pupil.—*London Review.*"

Now Mr Robb was himself the first to notice and watch the transformations of this insect, the larvæ of which he was astonished to find could feed and thrive on the poison-bean; he had sent home notes of his observations, and specimens of the bean and of the insects, for the examination of entomologists, and naturally felt, therefore, that the credit of the discovery, whatever that might be, belonged to himself. He also enclosed copies of these notes, which give details of the appearance and changes of the insect; and stated he was sure the only beans containing insects which had been sent from Old Calabar to Britain were the specimens which he had selected and sent home.

In the notes sent, Mr Robb states that it was in the end of the year 1863, while collecting the *Esere*, or poison-beans, that he noticed some of them were perforated by holes, showing apparently that some insect was able to live and feed on them. He made numerous observations on the beans eaten by insects, and found that some of them contained various grubs, as many as four or six being sometimes in one bean. He watched the progress of the caterpillars, seeing them spin their webs, change into pupæ, and at last emerge as perfect insects—a small grey moth, the Esere Moth, as he named it. He traced these transformations of the insect again and again, and noticed that chickens feeding on the excrements of the caterpillars were poisoned. Finding that his friend and colleague Mr Hewan was coming to this country, he gave him notes of his observations, and specimens of the beans, with their curious tenants, to bring under the notice of naturalists at home. He also gave specimens of the beans and insects to the late Rev. John Baillie, who followed Mr Hewan home, to allow the subject to be brought fully under the notice of scientific men.

Mr Hewan informed Dr Smith that he handed over Mr Robb's notes and specimens to the Botanical Society here; these notes were read at their meeting of 14th April 1864, and an abstract of them was afterwards published in their Transactions; but unfortunately, from Mr Hewan's absence, in bad health, in England, the authorship of the paper was erroneously attributed to him.

Dr Thomas R. Fraser, here, the author, in 1863, of a valuable treatise on the Calabar Bean, and apparently the gentleman referred to in the newspaper paragraph, published a communication "On the Moth of the Esere, or Ordeal-Bean of Old Calabar," in "The Annals and Magazine of Natural History" for May 1864, in which he states the fact of an insect feeding on the poison-bean, and gives details of its metamorphoses, &c., without being aware, apparently, of the paper read to the Botanical Society, or of the Rev. Mr Robb being the original observer, who had, at Old Calabar, watched the whole progress and development of the insect, and had sent home his notes and specimens to allow of its being described or identified by the entomologists of this country.

Dr Fraser, indeed, in his paper referred to above, stated that the beans, &c., were given to him by the Rev. John Baillie, who had returned from Old Calabar. Mr Baillie's bad health, and subsequent death, had apparently prevented him from giving Dr Fraser any history or details of the beans and insects he had got from Mr Robb.

Dr Fraser also mentions, that his friend Dr John Anderson got the insect or moth identified by the authorities of the British Museum as the *Deiopeia pulchella* (ord. *Lepidoptera*, fam. *Tineidæ*, Leach).

Of course, the discovery of an insect being able to feed and live on the poison-bean, and the description of its transformations, was due to the zeal and observation of the Rev. Alexander Robb of Old Calabar.

The specimens of the poison-beans eaten by the insects, and of the insects themselves, preserved in spirits, which were formerly sent home by the Rev. Alex. Robb, and were shown to the Botanical Society, were exhibited by Mr Hewan to the meeting.

The insects were then given to the Secretary for further examination.

Wednesday, February 28, 1866.—Mr William Turner, M.B., President, in the Chair.

The following Donations to the Library were laid on the table and thanks voted to the donors :—

1. Geologiske Undersogelser Bergens omegn af Th. Hiortdahl og M. Irgens—Udgivet efter det Academiske Collegiums Foranstaltning som Universitets—Program for Andet Halvaar 1862. Med et Tillœg om Fjeldstykket Mellem Lœerdal og urland samt om Profilet over Filefjeld Af Dr Theodor Kjerulf. Christiania. P. T. Mallings Bogtrykkeri. 1862.—2. Beskrivelse over Lophogaster typicus, en Maerkvaerdig Form af de Lavere Tifodde Krebsyr af Dr Michael Sars Professor ved Christianias Universitet. Christiania. 1862. From the Royal University of Christiania.—3. The Canadian Journal of Industry, Science, and Art. November 1865. From the Canadian Institute, Toronto.—4. Programme de la Société Batave de Philosophie Expérimentale de Rotterdam for 1865.—5. Geologist's Association. Annual Report for 1865. From the Council.—6. Vancouver Island Exploration, 1864. Printed by authority of the Government. From Robert Brown, Esq.—7. Transactions of the Royal Scottish Society of Arts. Vol. VII. Part 1. From the Society.

The following Communications were read :—

I. *Notice of the Physical Characters of Rupert District, Red River, Hudson Bay.* Communicated by William Rhind, Esq. With exhibition of Specimens, collected by Major George Seton.

Rupert's Land forms the south-west portion of that vast valley which surrounds Hudson Bay, North America. From the north border of Minnesota, a territory of the United States, and that slightly-elevated watershed where the head springs of the Mississippi River have their origin, the Red River also takes its rise, but flows north in a contrary direction to the Mississippi, passes through the centre of Rupert's Land, and terminates in Lake Winnipeg. From this river the district extends north-west and south towards the Rocky Mountains, with an area calculated at forty millions of acres. The face of the country is level, with a slight slope towards the north and east, the prevailing rock is a magnesian limestone, with fossils, belonging to the Upper Silurian system, of a white colour, sometimes of a chalky, and sometimes a cherty structure, is a good building-stone, and affords lime by burning, corresponding probably to the Landeilo strata of England. The strata form a series of low terraces rising in the direction of the Rocky Mountains. Above the lime-

stone lie irregular beds of sand and clay of a yellowish colour, and on the surface a deep black mould, which, when cultivated, forms a rich and fertile soil. These upper beds contain no fossiliferous remains ; on the surface are scattered a few granitic boulders, but none are found imbedded in the drift clay. At Beaver Creek and Pipestone Creek the clay drift is deeply cut through in the former to a depth of 200 feet; there are here slaty boulder stones, called Pipestones, and some large bones are reported to have been found, probably of cetacean animals. The flora of the district is rich and interesting, and from the collection of dried specimens exhibited, many of the families and some of the species common to Scotland may be recognised, as the ranunculus, violet, strawberry.

The buffalo, now becoming scarce in most parts of the continent, here exists in large herds, and a spirited drawing of one of these herds extending in dark lines and groups in the distance, with two bulls in front, gives a good idea of the vast multitudes of these animals which congregate in those extensive grazing plains.

" My sketch," says Major Seton, " is intended to represent a scene which *I saw on 8th August* 1858, *in lat.* 50° *north, long.* 104° *west.* But even to myself my sketch does not convey any idea of the numbers of bison presented to view on that occasion, for we looked down upon them more than in my sketch. On the 7th, as we journeyed along, we came to a few stray outlying bulls, scattered here and there miles apart, in the vast plains. These became more numerous, and might be seen on the low wooded ridges in twos and threes, and later on in the day we came to a small " band" of bisons, consisting of seven cows and a good many bulls. These we " ran," killing all the cows and a good many of the bulls, and one calf; for such is the practice of the half-bred hunters that they kill all they can. At this season the bulls and calf are of no use. Ere the tents were pitched and the meat cut and brought to camp, night had set in. Next morning we rode to the summit of a slight ridge, about three miles from the camp, and there saw what I have endeavoured to represent in the sketch. Con-

mencing not very far from the bottom of the ridge, the herd gradually thickened into long streaks and spots, bands and patches, until near the horizon the whole ground appeared to be covered, as far as the eye could reach, in front and from side to side, about 60° of the circle, with one continuous black mass of animals, which might be perceived to be gently moving in one direction, as they grazed and advanced and grazed again, in a general onward course.

"I measured a good many skulls which I found from time to time on the plains, and, taking four at random, the distance straight across the forehead, from the root of one horn to that of the other, was in one $9\frac{1}{2}$ inches, another $11\frac{1}{2}$ inches, 12 inches, and $12\frac{1}{2}$ inches. With such a broad front, and such a mass of wool and hair, which, on the bull's forehead, is at least 8 or 9 inches long, the bison has a formidable appearance. Yet I do not consider it a savage animal when let alone. The bulls sometimes allowed us to come very near (say 100 yards) without taking any notice of us, sometimes rolling on their backs or tossing the sand and earth, which the bulls were very fond of doing, as is shown by their horns, which are worn flat and smooth on the outside, and frayed into fringe at the upper part; they appear to stand for this purpose in one place, until a flat circular spot on the ground, about the diameter of their own length, is worn quite bare. These spots may be seen anywhere near the herds. When one approaches to within a short distance of the bull, he gives a steady look, and then turns and gallops off, tail in air, and all the others do the same, until there is a general rush."

The skull of one of the ancient human aborigines of the district, a Sioux Indian, taken from the site of a battle-field, was also shown in good preservation. The modern inhabitants of the district consist of the descendants of Scottish Sutherland Highlanders, who emigrated at the time of the depopulation of that county, about the beginning of the present century; of English settlers, and Americans from the United States. Their labours afford them every substantial necessary of life, but the remote situation precludes any reciprocity of trade with the busy world. The district, how-

ever, has great capabilities of agricultural production, and were its often-proposed railway communication extended from West Canada through this region, and over the Rocky Mountains to Oregon and California, it would then be effectually brought within the pale of civilisation. The climate is very healthy; the locality is intersected by the latitude of 50° north, and is thus on a parallel with the south of England. The summer is delightful; in winter the frost is severe, though less so than that of East Canada, but the atmosphere is clear, still, and steady, so that out-of-door exercise is always practicable and more pleasant than in the variable climate of Great Britain.

The Society is indebted for the interesting specimens here exhibited to the kindness of Major George Seton, who spent a year (1858) in the district, in the course of his official military duties. On a former occasion, some years ago, a large and interesting collection of Silurian fossils from Canada were brought before the Society from the same gentleman, who, in addition to his military duties, has so successfully employed his leisure hours in the investigation of the natural history of the countries he has visited. He is a Scotsman, was educated in Edinburgh, and has carried along with him through life those scientific acquirements for which he was distinguished when a student in this city.

A vote of thanks was given to Mr Rhind and Major Seton for the communication, and exhibition of specimens.

II. (1.) *Note of the Occurrence of the Death's-Head Moth in Roxburghshire, Perthshire, and Ross-shire.* By John Alex. Smith, M.D.

When residing in the neighbourhood of Melrose last autumn, Dr Smith got a caterpillar of the Death's-head Moth, the largest of the European Lepidopterous insects, which he placed in a basin with earth, and a few leaves of the potato, among the plants of which it had been found. On the 18th of August it buried itself in the earth, forming a large oval-shaped chamber, in which the caterpillar lay, and shortly afterwards changed into the large pupa now exhibited. It remained alive some time, but at last died.

The pupa measures $2\frac{5}{8}$ inches long, by $2\frac{1}{8}$ inches in its greatest circumference, about the middle of its length.

In the beginning of last October a box reached Dr S. containing a small-sized pupa, and the cast skin of a caterpillar of the Death's-head Moth, along with some dry leaves of the potato plant. A note from Mr D. M'Diarmid, Bridgeend of Alness, Ross-shire, dated 8th September 1855, informed Dr S. he had that day sent him "a live specimen of natural history unknown to every one there, even to the oldest inhabitant;—it was a very large species of caterpillar found among the potato plots of the village, and no less than four specimens of it had been observed." Mr M'Diarmid placed the caterpillar, along with some leaves for its food, in a box, and sent it to Dr Smith, to see if he could learn what the rare insect was. Unfortunately, the box did not reach Dr Smith until more than a month afterwards, and he found, instead of the caterpillar, the pupa (now exhibited); the poor half-starved larva having apparently become prematurely changed into the pupa state. It is therefore very much less in size than the one previously described, measuring only $1\frac{5}{8}$ inch long, by $1\frac{5}{8}$ inch in its greatest circumference, about the middle of its length. It remained alive for some time afterwards, but at last also died, without changing into the *imago* or perfect insect,—an event which seems very frequently to occur where the pupa is not kept in its natural state, deeply buried in the damp earth.

There is no doubt, from the smooth and regularly oval pupa, as well as from the skin of the caterpillar, cast off at its change into the pupa state—which displays, at the extremity of its body, the characteristic deflexed and tubercular horn, with its tip turned upwards—that this is also a pupa of the Death's-head Moth.

The two specimens of pupæ now exhibited are curious, as showing such a difference of size in the pupæ of the same insect.

Another specimen of the Death's-head Moth, the perfect insect, was sent to Dr Smith by the Rev. John Donaldson, it was found lying dead last September at Druimchastel farm, near Kinloch Rannoch, Perthshire.

The unusual occurrence of the Death's-head Moth at these different and distant places is curious, and forms an addition to the various instances recorded of its appearance, during last autumn, in different parts of Great Britain.

(2.) *Dr J. A. Smith exhibited a fine specimen of a* Lanius Excubitor, *the Great Grey Shrike, which was shot in the end of January by a keeper of Sir H. J. Seton Stuart, Bart., at Allanton, near Motherwell, Lanarkshire.*

Dr Smith was indebted to Messrs John Dickson and Son, Princes Street, the well-known gunmakers, for being able to exhibit the bird. It was the sixth or seventh specimen of this rare bird which had been observed this winter session, probably due to the prevalence of severe gales, bringing the birds from the continent of Europe.

Dr John Duns stated that, while passing through the Meadows here, on the 15th of February, he was attracted, near the Merchant Maiden Hospital, by the unusual cry of a bird. He saw the bird close to him, and, looking carefully among the trees, discovered it to be a Great Grey Shrike, thus adding another instance of its occurrence in this neighbourhood.

(3.) *Dr J. A. Smith exhibited a large specimen of the* Cyclopterus lumpus (*the Lumpsucker*).

A female, which is larger than the male, the Hush, or Hen-paidle of our fishermen, of unusual size for the Firth of Forth. It measured 19 inches in length and 11½ inches in its greatest depth, and weighed nearly ten lbs. avoirdupois, being full of spawn. It was taken by a small haddock line, a little to the east of Inchkeith, on the 24th of January; and was kindly sent to Dr Smith from Mr Muirhead, Queen Street, and has now been preserved for our important Museum of Science and Art.

Dr Parnell, in his "Fishes of the Forth," says:—"This fish seldom takes a bait, and is generally taken in the salmon nets about the month of June, and entirely disappears after the month of August."

(4.) ***Notes of the Insects which feed on the Esere, or Ordeal-Bean of Old Calabar.*** By John Alex. Smith, M.D.

At the last meeting of the Society Dr Smith read extracts from a letter he had received from the Rev. Alexander Robb of Old Calabar, in reference to his discovery of insects feeding on the Esere, or Poison-bean; and at the same time Dr Hewan exhibited the specimens of these insects which he had got from Mr Robb and brought home for examination.

Dr Smith was rather surprised at the apparent discrepancy of Mr Robb's description of the insect as a small grey moth, with that of the insects also given by Mr Robb to the late Rev. Mr Baillie, and by him to Dr Thomas R. Fraser, which had been described as being the Crimson-speckled Footman Moth,—the *Deiopeia pulchella.* Dr Thomas R. Fraser, in his paper published in the "Annals and Magazine of Natural History" for May 1864, gives the following account of the insects found feeding on the Calabar bean received by him from the Rev. Mr Baillie:—"I am indebted to my friend, Dr John Anderson of this city, for the identification of this moth. Specimens of the caterpillar, cocoons, and imago, were kindly sent by him to the British Museum, and were pronounced by the authorities of the insect department to be the *Deiopeia pulchella* (ord. *Lepidoptera*, fam. *Tineidæ*, Leach). The description and figure given in the fourth volume of Curtis's 'British Entomology' appears to correspond accurately with the imago in my possession."

Dr Smith got the phial containing the insects (caterpillars, pupæ, and moths) from Dr Hewan for examination, and found:—

1. The *Caterpillars* varied considerably in size, but they were all of the smooth and *naked* character to be expected in the inhabitants of tunnels cut by themselves in the hard seeds or kernels of the poison-beans, and none of them appeared to resemble the *hairy* larvæ of *Deiopeia pulchella.* They measured from about $\frac{1}{4}$th of an inch to $\frac{7}{8}$ths or nearly an inch in length, and differed proportionally in thickness from $\frac{1}{20}$th to $\frac{3}{20}$ths of an inch, probably the same caterpillar of different ages, as the markings on all were alike. The

skin yellowish-white, smooth, and naked. The head small, horny, black or dark brown, and shining; a long black spot or horny collar, tapering towards each extremity, occupied the centre of the first segment of the body; two rows of very small spots, or dots of black (two pairs on each segment of the body) run longitudinally along the back on each side of the mesial line, and a cluster of three small spots, arranged in a perpendicular direction, on the sides of each segment of the body. There is also a dark horny patch on the upper part of the last segment of the caterpillar, and on the second last segment there is a smaller dark horny square-shaped patch in the centre, with a small circular spot or dot of black on each side of it. The thoracic feet are 3 on each side = 6; then two segments without feet intervene; next we have 4 abdominal feet on each side = 8; then 3 segments without feet, and on the last segment are the 2 anal feet = 2 = 16 feet.

There was one *cocoon* in the phial, oval in shape, and rather more than $\frac{3}{4}$ths of an inch in length by about $\frac{1}{4}$th of an inch in breadth, of fine brownish-coloured silk, which enclosed one of the larger-sized caterpillars on the point of being transformed into the pupa state. The caterpillars and pupæ seemed possibly to belong to the family *Tortricidæ* of Westwood's "Classification of Insects," in which are included various feeders on fruits.

2. Two kinds of *Pupæ* were, however, found in the phial, —*one*, oval and smooth in character, the others showing various small projecting spines. This single specimen of pupa, oval, regular, and tapering in outline, was nearly $\frac{5}{8}$ths of an inch in length, of a darkish brown or black colour, with (seven) transverse belts of a lighter brown along the lower part of its different segments, and terminated behind in two very small forks or teeth-like processes; it reminds one of a small pupa of the common gooseberry moth.

Three others, and a portion of a fourth, more slender and smaller pupæ, are somewhat oval in shape, of a light-brown colour, and about half an inch in length. They have two small lateral rather blunt projections or horns on the posterior part of the head, and another slighter projection in the

middle forming part of a ridge or row of small projecting points, which runs down the middle of the back of the thorax. A shorter projecting line of points runs parallel to this one, on each side. There are two projecting points which lie behind this central ridge, and form the first of a series of pairs of small processes on each segment, and on each side of the mesial line of the back of the abdomen. The abdomen terminates posteriorly in two sharp and slightly bent hook-like processes.

3. The *Moths* or perfect insects were much destroyed by being kept long in spirit, so that it was only with great difficulty, and by comparing one with another, that an attempt could be made to describe them. Their appearance was generally that of long-shaped, greyish-coloured moths, and they differed altogether from *Deiopeia pulchella*. They varied slightly in size. Several measured about $\frac{3}{8}$ths of an inch in length, while others were apparently a little more than $\frac{4}{8}$ths; and one which, however, wanted the head, was about $\frac{3}{8}$ths or so in length; differences probably simply sexual in character. The head is small, eyes large, antennæ long and filiform, with a series of comb-like processes projecting from their lower edge, and becoming gradually shorter towards their extremities, which are simple, having no projecting processes. The fore legs have apparently a pair of spurs projecting from about the middle of the tibiæ; the second have a pair of terminal tibial spurs; and the third, a pair springing below the middle, and also a terminal pair of tibial spurs. The wings are narrow, parallel to body, and, when closed, apparently cover the abdomen, which is large and full. The general colour of the insect appears to be grey, or greyish brown, with probably a longitudinal stripe of a darker colour, brown or black, along each side of the thorax above, leaving a light-coloured space in the middle; the wings grey, with a somewhat triangularly shaped patch of black across their posterior and external angles, and a black line or edge proceeding from it along the whole posterior margin. The lower wing shows the same character, but apparently less distinctly marked.

As there could be no doubt of the insect described by Dr Fraser being the *Deiopeia pulchella*, and being also given by Mr Robb to Mr Baillie apparently as a feeder on the Calabar bean, it appeared probable, from the character of its larva, that this widely spread insect might feed merely on the foliage of the plant; while the naked larvæ and the moths now exhibited, still undetermined, were probably those which cut the tunnels and fed on the interior of the poison-bean itself.

At this rather unexpected result of the examination, Dr Smith had written to the Rev. Alexander Robb of Old Calabar, asking him, if possible, to rear again the insects that feed on the Esere, and keep the different caterpillars, their pupæ, and perfect insects or moths, isolated and distinct from one another, so that entomologists might know the series of each, and send them to this country for the determination of their species,—as there appeared to be little doubt that the insects feeding on the Calabar bean still required to be discriminated and described.

Being but little of an entomologist, Dr Smith asked our member and well-known entomologist, Mr R. F. Logan, to examine the species of insects in Dr Hewan's phial, and he had received from him the following reply:—"I have carefully examined your insects from the ordeal-bean, and find that there are at least three different species mixed up in the various states of larva, pupa, and perfect insect; and it would be hard to say, in their present condition, which belongs to which. There are two very distinct pupæ, one of which probably belongs to the *Geometrina*. The other, of which there are several specimens, from some of which the moths have escaped, appears to belong to the *Torticina* or *Pyralidina*, and may be that of the larger caterpillar. The very small larva seems distinct, and is probably a *Tortrix* or *Tinea;* and there seems to be more than one species among the moths; but, drowned in spirits, and with all their scales off, it is impossible to say much about them. One thing only is pretty evident—they are not *Deiopeia pulchella*"

We must therefore wait until additional and more perfect specimens of these insects are sent from Old Calabar before

it can be decided how many, and what, are the species of moths whose larvæ can feed and thrive on the poison-bean of Old Calabar.

Since this communication was read to the Society the Rev. Alexander Robb has returned to this country, and informs Dr Smith that—sitting one evening in his room, at Old Calabar, a pretty specimen of a gaily spotted moth—a common species there—flew to the table and was captured by him ; one of the phials containing the insects collected from the Esere, and filled with spirits, was beside him, and into it he popped his recent capture. He gave this particular phial to the Rev. John Baillie, who was just leaving for home, and informed him that, with the single exception of this insect, all the others were feeders on the poison-bean. Mr Baillie was in delicate health, which probably caused him to forget all about the matter ; and it is rather a curious result, that the only insect which had nothing to do with the Esere, being the most recent capture, and therefore in the best state of preservation, should naturally be the only one examined and named, the well-known *Deiopeia pulchella,* and in this way come to be described and published in the "Annals and Magazine of Natural History," vol. viii. third series, 1864, as the newly discovered feeder on the poison-bean of Old Calabar.

III. *Note on a Communication by Dr J. A. Smith, entitled "Notes on the Discovery by the Rev. Alexander Robb, in* 1863, *of an Insect feeding on the Ordeal or Poison Bean of Calabar."* By THOMAS R. FRASER, M.D. Communicated by WILLIAM TURNER, M.B., President Royal Physical Society.

In the note read by Dr Smith at last meeting of the Society, the author's name is introduced in such a manner as to suggest the idea that he had asserted a priority in the discovery of the Esere Moth. This communication is intended to explain Dr Fraser's connection with the matter. The Rev. John Baillie brought from Calabar a parcel containing a number of ordeal-beans apparently injured by an insect, and presented them to Dr Fraser, who published a

paper on the subject in the "Annals and Magazine of Natural History." Until the appearance of Dr Smith's "Notes" Dr Fraser was ignorant of any other publication, and he is now informed that a short paper on the Esere insect, written by the Rev. Alexander Robb, was read before the Botanical Society, in Dr Hewan's name, on the 14th of April, and published in page 181 of the volume of Transactions issued in November 1864. As the author's paper was in the hands of the editors of the "Annals" about the middle of April, and was published in May 1864, it is obvious that it could not have been influenced by Mr Robb's communication. The Rev. John Baillie did not refer to Mr Robb's observations, and yet Dr Fraser informed him of his intention to publish anything which he might find of interest. Nor did Dr Hewan mention the existence of these notes when spoken to on the subject of the insect, at a casual meeting, previous to the reading and publication of both papers. There was no other source through which this information could have been obtained. Dr Fraser has never claimed to be the discoverer of this moth. It would have been absurd for him to do so, as he mentions in his paper that he received beans and insects, and the principal facts of the connection between the two, from the Rev. John Baillie. He would have acknowledged the existence of the Rev. Alexander Robb's notes with the greatest pleasure had he known of them, but a previous acquaintance with these notes would not in any other manner have influenced his communication.

IV. (1.) *Notice of the Nests of two Exotic Spiders.* By ADAM WHITE, Esq., late of British Museum.

Mr Adam White made some remarks on the cocoons of spiders, on their various forms, and on the different circumstances in which they were left or closely kept by the mother-spider. He alluded to the silken thread from certain spiders' cocoons being the finest line that could be procured for micrometrical purposes by the optician, astronomer, and microscopist. He exhibited drawings of two remarkably

beautiful and symmetrical spider cocoons, drawn by himself from the original nests. One was from Greece, covered by six of the curious shield-like expanded seeds of the *Paliurus;* the other was from Pernambuco in Brazil. It was exceedingly pretty, suspended by a long spider-woven rope, with a conical roof symmetrically sealed, and then ending in a reversed cone which tapered very gradually to a point. His friends, Messrs Saunders and Weilenmann of St Gall, found these respective nests. Mr White concluded by making a remark on the regularity of what might be called the spider-mind.

(2.) ***Notes on the Appearance and Migration of some of the Birds of East Lothian.*** **By R. Scot Skirving, Esq. of Camptown. Communicated by Adam White, Esq.**

Towards the end of autumn unusual numbers of our more common visitants arrived, and at the same time a considerable number of rarer species. A good many of the latter have found their way (or rather, poor things, it has been found for them) to the George Street bird-stuffers, where perhaps you may have seen them. Foremost among these was a fine example of the Crane shot in Shetland, which, I am glad to say, has been presented to our Museum, which had not a specimen of the bird. The Great Spotted Woodpecker and the Waxwing were contributed by this county, where also the Great Grey Shrike has been unusually common. I watched one of these butcher-birds for several hours, in hopes of seeing him kill and stick up his prey, but failed to do so. I may mention that I have observed this bird, like many others which are solitary here, is to a great extent gregarious in Syria. On the shores of the Sea of Galilee I observed them in great numbers, and I had reason to believe that they built their nests in colonies in thick thorn bushes, and not on high trees, as several books on natural history state. The only visitor I plead guilty to having "obtained," as the phrase is, is the Skua Gull, which is now becoming exceedingly rare, even in his two famous habitats in the remoter Shetlands. I had never before seen

a specimen, but he gave me at once ample proof what manner of bird he was. I saw him at first, a dark object, floating in the sea, some hundred yards off. He rose at a distance, and flew after a Herring Gull. To my surprise he struck it dead at the first swoop, and, immediately pouncing upon it, shook and tore it more as a dog worries, than as a hawk tears. I now regret that I shot him while so occupied, as I see Yarrell mentions an exactly similar case, where the Skua was so engrossed as to let himself be taken with the hand. He was much broader and more strongly built than the Herring Gull, but had a less expanse of wing.

Wood Pigeons appeared in November in numbers which, unless seen, would seem fabulous, and, however unpopular among farmers the opinion may be, I firmly believe many of these birds come from abroad. It is only in exceptional years, however, that the influx from beyond seas is large. This year it was prodigious, and the newly-arrived multitudes were at first quite ignorant of guns. Wood Pigeons are the locusts of Scottish agriculture. Next in number have been the Thrushes, which are unusually abundant. Of these, the Fieldfare, the most numerous and yet the weakest of its tribe, has hitherto escaped the storms of frost and snow which invariably strew the fields with their dead. I presume it is chiefly the first year's birds which are so easily starved.

What has struck me as the most remarkable incident with regard to the Thrushes is, that I have, for the first time, heard the song of the *Missel* Thrush.

Mr Wood, in his "Natural History" (Birds), describes the Missel's song as "rich, loud, clear, and ringing, and that it is heard in the roughest and most inclement weather." Now, though the Missel is one of our most familiar birds, I never heard it utter a sound save its harsh scream of warning and alarm, till this winter. I was riding to the fox-hounds, when I was startled by a bird-song that I was instantly certain I had never before heard. I turned aside and rode in the direction, and was astonished to find the voice was that of a Missel perched on the top of a tree. The notes were as Mr Wood describes—less varied than those of the song-

thrush, but very greatly more powerful. Whatever be the habit of the bird in England, I am certain it seldom favours us with its song in Scotland, and upon that subject I should be obliged if you could give any information. The song-thrush sings occasionally in winter, but we are not accustomed to hear birds singing in the midst of snow-storms.

VI *On Spines and Plates of a* Synapta (Chiradota *of Esch.*), *from the Stomach of a Flat-fish, taken off the East Coast of Scotland.* By CHARLES W. PEACH, Esq.

Although several specimens of *Synapta* have been taken on the west coast of Scotland, I can find no notice of their occurrence on the east side. Having found the plates and spines of one in the stomach of a flat-fish from the east coast, I have thought it right to lay the discovery before the Society, in the hope of inducing others to look out for living specimens from that part.

The spines now exhibited are those of *Synapta inhærens* of Müller. I refrain from farther particulars about them, beyond saying that, although the specimens were few, I found anchors attached to plates, as well as loose plates and detached anchors. They agreed with those figured in the paper of Woodward and Barrett, which will be mentioned in the list which follows. As the history of these curious animals is scattered through various publications, I hope it will not be unacceptable to those who take an interest in the subject, and useful to them as a reference to British species.

First, then, Woodward and Barrett's paper, published in the "Proceedings of the Zoological Society of London," July 13, 1858 :—

1. *Synapta digitata,* Montagu. First found by Montagu in South Devon. Mr Joshua Alder got it in abundance, in 1844, in Rothesay Bay; and in 1845, in Torbay, Devonshire. Mr Bailie dredged it in Biterbury Bay, and at the Arran Isles, on the west coast of Ireland. The Rev. Charles Kingsley got it, in January 1854, near Torquay. Mr W. P. Cocks found it, in blue mud and sand, at Helford, also at

Falmouth. It appears to range to the Mediterranean, and has been found in several other foreign stations.

2. *Synapta inhærens*, O. F. Müller. First found at Christiansand, Norway, and described in the "Zoologica Danica," 1781. Mr Henslow first got it at Aberystwith and Criccieth, in North Wales, and communicated it to Dr Leach in 1819, who named it *Jemania Henslowanii*. It was also got in the latter locality, by Mr J. W. Wilton, in 1856. In February 1856, Mr E. C. Buckland got it in Lihon Bay, Guernsey. "A microscopic preparation of the skin of this specimen shows 150 anchors in the field of the one-inch object-glass." Mr Cocks got at Falmouth. Mr M'Andrew in Bantry Bay, in August 1857. So far for the above paper.

3. *Synapta Gallieni vel Sarniensis*. At the meeting of the British Association in Bath, in 1864, Dr Herapath described a species got in Bellegrave Bay, Guernsey, by M. Galliene, and has fully described and figured it in the "Quarterly Journal of the Microscopical Society" for 1865, new series. This has also been taken by Dr M'Intosh at North Uist, in the Hebrides.

4. Dr Herapath mentions, in his paper, one taken by Professor Wyville Thomson in Ireland, and wishes it to be named *Synapta Thomsonii*.

5. *Synapta Buskei*, M'Intosh. Found by Dr M'Intosh in Lochmaddy, North Uist, Outer Hebrides, and described by him in the "Proceedings of the Royal Society of Edinburgh," vol. v. (1862–65), p. 612, fig. 6.

Thus, then, although many others have been found in other parts of the world, at present only five species have been found on the British coasts; and although few, their spines, &c., make such beautiful microscopic objects, they are well worth searching for.

I must here express my best thanks to Dr Wm. Carpenter, for the use of Woodward and Barrett's paper, and to Dr J. A. Smith, for the "Proceedings of the Royal Society of Edinburgh." For Dr Herapath's paper I am indebted to the University Library authorities.

Wednesday, March 28, 1866.—WILLIAM TURNER, M.B., President, in the Chair.

The following Donations to the Library were laid on the Table, and thanks voted to the Donors:—

1. Proceedings of the Royal Society. Nos. 78, 79, 80.—From the Society. 2. The Conservatory Journal, Boston, 1859. Nos. 1, 3, 4. 3. Board of Science, Second Annual Report, 1859–60. Victoria.—From The Colonial Government. 4. Quarterly Journal, Geological Society. 13 Numbers.—From Professor Balfour.

The Ray Society's Works were also laid on the table:—(1.) Reptiles of British India, by Dr Günther. 1864. (2.) The British Hemiptera. Vol I., Hemiptera—Heteroptera, by John William Douglas and John Scott.

The following Communications were read:—

I. (1.) *Notes on certain Spiral Forms.* By WILLIAM STEVENSON, Esq., Dunse. Communicated by GEORGE LOGAN, Esq., W.S.

Every one walking by the side of a flooded river, must have observed the cup-shaped depressions formed by the eddying of the current. Wherever the stream meets with an obstacle on either side, a portion of it is deflected back, and whirls round, until it comes in contact with the main current, when it is again deflected, producing one of the depressions referred to. These, it will be observed, are not strictly circular in horizontal section, but *spiral.* It will be further observed, that on the right bank of the stream the spiral motion is from left to right, or similar to that of the hands of a watch, whilst on the left bank the motion is from right to left. The cause of this is sufficiently obvious.

On examining the gravel thrown down by flooded streams, it will further be observed that these deposits, which appear to a casual observer to be about the most confused and irregular things in nature, actually show a beautiful spiral arrangement—the turns of the spirals being from left to right on the right bank, and *vice versa* on the left,—these spirals also being generally of an elliptical form, the major axis pointing up and down stream.

When a cartload of stones is emptied at once in a heap, even in this case the spiral arrangement is distinctly seen—the stones being arranged in right or left hand spirals,

according to the way in which the cart was turned in throwing them out. The metal upon a macadamised road also shows the same arrangement.

The currents of the atmosphere likewise exhibit the same phenomenon. As is well known, the storms of southern latitudes revolve from left to right, whilst those north of the Equator revolve in an opposite direction. These revolving storms, to which the term "cyclones" has been applied, appear to be truly of *spiral* form. This has been all but demonstrated by the able and laborious researches of Mr Buchan, secretary to the Scottish Meteorological Society, (*vide* his paper in the "Transactions of the Royal Society of Edinburgh," read 3d April 1865), and will probably be soon placed beyond a doubt.

It is not the object of this short paper to enter into any investigation as to the exact manner in which the spiral forms in question are produced, but simply to call attention to a subject which seems, so far as the author is aware, to have been overlooked by even the most acute observers of physical phenomena, but the study of which will be found highly interesting as well as instructive.

(2.) Mr George Logan *exhibited specimens of Fossil Plants from the Upper Old Red Sandstone, near Dunse; with Notes* by William Stevenson, Esq., Dunse.

The two specimens of vegetable fossils exhibited are from the Upper Old Red Sandstone of Prestonhaugh (between two and three miles north of Dunse). In the same beds a fine specimen of the *Cyclopteris Hibernica* was found a few years ago by Mr Stewart, Edinburgh, who presented it to Hugh Miller, in whose collection I saw it shortly afterwards. Though common in the Irish Devonian strata, I believe that no other specimen has been found in Scotland. In the Prestonhaugh beds are many obscure vegetable remains, apparently fucoids, some of large size. Associated with these are remains of the *Holoptychius nobilissimus, Pterichthys major*, &c., characteristic of the Upper Old Red. Several of the strata are beautifully rippled, and some show cracks

due to desiccation, curious worm-trails, &c., and indicating littoral deposition. The specimens sent are, I consider, very interesting, though obscure; and I hope that some one of our Society may be able to determine the species. I have not a copy of Colonel Portlock's "Memoir on the Irish Devonians" to refer to; but I think it likely that these fossils will be found to agree with some of the Irish species described by him.

The fossils exhibited were considered by the members present to be specimens of *Cyclopteris.*

Mr C. W. Peach stated he had specimens of *Cyclopteris,* which he had found at John o' Groat's, in the north of Scotland.

II. *On a Bone Cave at Lower Warburton, Kincardineshire.* By James C. Howden, M.D. Communicated by James M'Bain, M.D., R.N.

In the year 1847 a cave was discovered in a range of trap cliffs on the farm of Lower Warburton, in the parish of St Cyrus, Kincardineshire. The entrance to the cave faces due south, is about half a mile from the estuary of the North Esk, and fifteen feet above high-water mark. A short account of it was given by Mr Alexander Bryson in 1850, and will be found in the "Edinburgh New Philosophical Journal" for that year. He says—"The mouth of the cave, on the occasion of my visit, was entirely filled with soil, richly stored with the bones of the ox, deer, badger, hare, rabbit, and other smaller rodents, also a few bones of birds. Immediately at the mouth or lowest part of the cave, the bones consisted mostly of those belonging to the larger ruminantia; while at the height of three feet, the remains were those of smaller rodents, so particularly arranged as to attract our notice. Although the whole mass of rich mould filling up the mouth of the cave, and extending to the height of ten feet, teems with the remains of animals, yet a degree of stratification obtains. The skulls of the rat and other smaller rodents are mixed most liberally and promiscuously through the whole mass; not so the scapulæ and the lighter bones; these are most curiously

congregated in heaps, so that a spadeful could easily be obtained without the slightest admixture of earth or foreign matter. . . . . We were rewarded by the discovery of an inner cave on a level with the entrance of the first. This cave was of small dimensions, and had, before the deposition of the bony debris (?) been closed by a detached piece of rock from above. In this small chamber we could find no traces of bones—a slight unctuous slime covered its floor, stuck full of *Buccinum*, *Mytilus*, and *Patella*. The only indications of humanity discovered in the bony debris was a vertebral bone of an ox, which bore evident traces of being sawn or ground flat; also an amulet, formed rudely from the leg-bone of an ox."

At the meeting of the British Association in Aberdeen in 1859, the late Mr William Beattie of Montrose read a short notice of the Warburton Cave, from which I extract the following statements:—"The entrance to the cave," Mr Beattie says, "is through a hard compact rock of trap, and measures 12 feet wide by 5 feet high. On entering, the cavity suddenly widens out to 20 feet, with a height varying from 20 to 30 feet—the whole having been crammed to the roof with a deposit of fine, dark, loamy soil, containing a variety of organic remains. The bottom or floor consisted of round stones or sea-beach; in some places mixed or covered with stalagmitic concretion several inches thick. The lowest stratum, 3 feet deep, was composed of dark loam, with admixture of decayed shells, principally of *Mytilus edulis*. Above this, extending round the cave, was a remarkable layer of *Patella vulgata*, varying from one to three feet deep, all in the finest state of preservation and of a large size, many of them measuring two inches across. This extraordinary deposit of shells contained no admixture of sand or earthy matter, but lay pure and clean, *as if heaped together by human agency*. A few examples of *Turbo littorea* were since picked up. About eight feet from the floor we found a stratum of decayed animal matter, about a foot deep, with a layer of bones extending throughout the whole width of the cave. The teeth and bones were discovered in this

layer, and, so far as yet discovered, they belong chiefly to the ruminantia. . . . . *The whole of the bones have been shattered, except the joints and other solid parts ; on these we observed marks as if they had been gnawed by some animal.* The only examples of the carnivora yet met with are, the head of a wild cat, and the jaws of a fox or wolf (or dog?), with teeth belonging to animals of a larger species.

"About a foot from the floor we turned up part of the left parietal bone of a human skull, extremely thin, but compact, firm, and smooth as a piece of ivory. Two small pieces of a pipkin were also picked up, bearing evident marks of antiquity."

When Mr Beattie had read his communication, Professor Owen remarked that all the bones he had examined were those of existing species. How the bones of the deer, the sheep, the hog, the fox, the dog, the cat, and many other quadrupeds, as well as birds, came to be mixed together in that cave, he was unable to explain; *also by what animal the larger bones could be so completely crushed, that the teeth, joints, or other hard parts in which there was no marrow, alone remained.*

The descriptions of Mr Bryson and Mr Beattie differ, it will be observed, in some points. Mr Bryson states that the shelly deposit was found in an inner cave, while the bones, &c., were in the outer or larger compartment. Mr Beattie takes no notice of this inner cave. Mr Bryson's account is likely to be the more correct of the two, for it was written shortly after a visit to the cave, while it was yet open; whereas Mr Beattie wrote from the recollection of what he had seen ten years before, his memory being unaided by notes. It must be observed, however, that both these gentlemen had espoused different theories, and that it is not unlikely that the attention of each was most strongly directed to the points which best supported his views.

At Mr Beattie's instigation, the proprietor, Captain J. Fitzmaurice Scott, employed workmen to have the cave cleared out; but, unfortunately, during their operations the

roof fell in, and thus precluded further research. I had not an opportunity of visiting it before this catastrophe took place, so that my own personal observations are confined to an examination of the remains in the Montrose Museum, and of the debris still scattered about the entrance of the cave.

Mr Bryson's idea was, that the shells in the inner cave had accumulated there when the land was at a lower level, and when, in consequence, the sea had access to it—that then a partial elevation took place, when the North Esk flowed past the bottom of the cliff, and carried in by an eddy the bones and other materials which blocked up the outer cave. It is unnecessary to combat Mr Bryson's views, the more so that I believe no one is now more convinced of their fallacy than himself. Mr Beattie again adopted the opinion that this had been a hyena cave like that of Kirkdale; and it was the promulgation of this theory, so utterly incompatible with the character of the bones, which caused his otherwise important communication to the Aberdeen meeting to be overlooked.

My first visit to the cave was made in company with Mr Beattie, and the shrewd tenant of the farm, Mr Walker, who had ere then utilised the bulk of the debris as top-dressing. Mr Walker was unacquainted with Dr Buckland's discoveries, but expressed his own opinion, that this collection of bones and shells was nothing more than a "midden." Though I was not then aware of the discoveries made in Denmark by Steenstrup, Forchhammer, and Worsöæ, on the Kjökken-möddings, I could not help admitting that Mr Walker's humble theory was more tenable than either of those formerly alluded to. When I read the able article by Sir John Lubbock, in the "National History Review" for October 1861, on the Danish Kjökken-möddings, the true history of the Warburton case appeared to me at once explained; and in the following summer, when I had an opportunity of inspecting the collections from the Kjökken-möddings, preserved in the Copenhagen Museum, I was still more convinced that the contents of the cave must

have been accumulated by man under similar circumstances.

The cave, ever since I knew it, has been completely closed up by a large mass of rock several tons weight; but around the entrance, the soil still abounds in fragments of bones, shells, wood-ashes, &c.

Fortunately Mr Beattie preserved, in the Montrose Museum, a considerable quantity of the debris at the time the cave was open, and a study of this, as well as of the fragments since picked up by myself, will, I think, bear me out in my interpretation of its history. It will be observed that Mr Bryson and Mr Beattie both, unintentionally as it were, give evidence in favour of the human theory, and against their own. Mr Bryson refers to the arrangement, or "stratification" as he calls it, of the different kinds of materials; to the bone of an ox, which "bore evident traces of being sawn or ground flat," and to "an amulet formed rudely of the leg bone of an ox." Mr Beattie again states, that "this extraordinary deposit of shells contained no admixture of sand or earthy matter, but lay pure and clean as if heaped together by human agency. The following list comprehends most of the animal remains preserved, viz.:—Shells of *Mytilus edulis, Cardium edule, Litorina littorea, Buccinum undatum, Fusus antiquus, Patella vulgata, Helix nemoralis;* fragments of the claws of *Cancer pagurus;* leg bones and bills of *Sula bassana;* bones of *Cervus elephus, Cervus capreolus, Sus* ——, *Erinaceus europeus, Bos* ——, *Felis catus, Canis familiaris, Canis vulpes, Hypudæus* ——, *Mus* (?) ——; and a portion of a human parietal bone and radius.

The shells of the mollusca are all of large individuals, particularly those of *Patella vulgata.* At the present time the beach nearest the cave is either shingly or flat and sandy, and it is not till you go several miles north or south that you come to the habitat of the marine species above mentioned. The same remark applies to the edible crab, which does not live within two miles of the cave.

The frequency of the bones of the solan goose is remarkable. This bird only visits these shores in summer, when it is often

taken in the fishermen's nets. The absence of the wild goose and other common species might be explained by supposing that the cave frequenters were not acquainted with the use of weapons which enabled them to kill such wary birds, and that they only occasionally caught a solan goose in the process of fishing. Neither Mr Bryson nor Mr Beattie notice the occurrence of fish bones in the cave, nor is there a vestige of any among the remains preserved in the museum. The leg and wing bones of the solan goose are sometimes entire, and sometimes broken across, but in *no instance are they split open.*

The bones of the mammalia consist chiefly of fragments of the long bones, and the shafts of the marrow bones are *invariably split open.* The articulating ends of the hinge-joints are generally attached to the shafts, and are entire; but the spongy ends of the ball and socket-joints, as of the humerus and femur, are detached and more or less destroyed, either by the gnawing of some animal or by natural decay. The human bones are in very good preservation; the piece of radius is 7 inches in length, and is not split open. There are several fragments of calcined bones, but I am unable to determine whether these belong to the human skeleton or not. The two fragments of coarse pottery are both ornamented outside with a small cord pattern; one, which is charred inside, has been part of a vessel 10 inches in diameter; the other is not charred, and has measured 7 inches in diameter. Flat, oval, or round rolled stones are abundant; on none of these have I detected the chipped edges noticed on the Kjökken-möddings stones, and supposed to be evidence of their having been used in the formation of flint implements.

There are few parts of Scotland richer in the remains of the stone period than Angus and Mearns. In some localities implements or flint flakes are turned up at every ploughing of the fields. The absence of flint from the cave collection is not of great moment, for it must be borne in mind that not a thousandth part of the debris was preserved, or examined; and it is quite likely that stone implements and

many other important objects might have rewarded a more careful search.

No Kjökken-möddings have been found on the coasts of Angus and Mearns; but it is not likely that the early inhabitants would adopt the open air pic-nic habits of their contemporaries on the flat shores of Denmark or the Moray Firth, when they could get the shelter of a cave like that of Warburton, so well suited for human occupation, facing as it does due south, sheltered from the north and easterly blasts, and elevated above the surrounding land, so as to afford good drainage. On these cliffs the primrose, the violet, and the *Ranunculus ficaria* bloom several weeks earlier than in the surrounding country; good water can be got at a few yards distance; while the proximity of the sea, river, and forests, would afford the means of supplying the wants of a primitive race.

The occurrence of human bones raises the question of cannibalism; but I do not think that the facts before us are sufficient to enable us to answer it one way or other. The mere presence of these bones is strong presumptive evidence; but it is quite possible that the cave may have been used for the concealment of the victim of some modern murder.

After it was deserted as a human abode, the gradual decay of the rock, the filtering of water with soil through cracks in the roof, and the eddies of wind carrying in the debris scattered round its entrance, are sufficient to explain how the cave happened to be filled to the roof, as it was on its discovery in 1847.

Mr Bryson found, at the entrance of the cave, some iron bolts, and the remains of an iron harpoon or spear. If these were in such a position as to convince us that they were contemporaneous with the bones, the date of the cave would be brought down to a much more recent period than the Kjökken-möddings; but I think, with this single exception, all the evidence goes to prove that the occupiers of the cave had similar habits, and were in a similar stage of civilisation, with the constructors of the Danish middens.

Above, and in the neighbourhood of these cliffs, there are at the present day several cottages occupied by salmon-fishers, and it seems to me highly probable that the pieces of iron found at the mouth of the cave may have been part of the boat gear of some of the actual or recent inhabitants. If, however, the iron was mixed up with the debris inside the cave, we must suppose that these bone-splitters were not limited to stone implements, and that the Kjökken-mödding habits were by no means confined to the so-called stone epoch. The remarkably perfect state of preservation of many of the bones is scarcely compatible with great antiquity. We know that in America, New Zealand, &c., Kjökken-möddings are being formed at the present day; and that so near home as the Hebrides, pottery much ruder than that found in the Warburton cave is in actual use. That the so-called stone, bronze, and iron epochs were clearly separated from each other is probably an archæological myth; and we have yet to learn when implements of the two first kinds ceased to be generally used in this country.

In conclusion, then, we are, I think, justified in supposing that this cave was used as a human habitation, and that its occupiers had similar habits to the formers of the Danish Kjökkenmöddings. On the other hand, we have no evidence of great antiquity, nor, indeed, any indication of the probable age at which it was occupied.

III. *On the Life of a Domestic Cat.* By William Brown, Esq., F.R.C.S.E.

The domestic cat is generally considered to be an ignoble animal. By the title-page of "Punch," the dog has a world-wide reputation; and one volume after another has been dedicated to his races, instincts, and virtues. But the cat is viewed by authors as merely a household drudge, and is associated in companionship with cheerless old age. It is perhaps this general contempt, on the part of literary men, which has exposed the animal to the infliction of cruelty, and to ill usage of all kinds. It is always at hand—always *convenient*, as Irishmen say—the readiest living object

on whom to vent a mischievous humour; and the popular myth that a cat has nine lives, deadens the conscience of the thoughtless boy, and of others besides boys.

But the cat is not only a useful animal, holding the place in the world of living beings which has been assigned to it by the Creator. It has social qualities of a high order; and if the dog is rightly characterised as being man's companion on the road and in the field, the cat is equally entitled to be considered as his companion in the house.

I have no intention to ascribe to the cat qualities which she does not possess. We usually say *she*, perhaps because the cat is so much associated with females in domestic life. Her softer skin unfits her for many of the rough out-of-door occupations in which the dog is concerned. But her limbs have more flexibility; and her whole structure is arranged for the kind of life which has been designed for her. The dexterity which she shows in some of those actions, which we call thefts, is very remarkable. The neatness with which she presents her soft paw to a friend, while it is transformed into a powerful weapon of offence to an enemy, cannot be forgotten by any one. The noiselessness of her movements, when she has any purpose to serve, is not excelled by any other animal.

She must be held much inferior to the dog in intelligence and fidelity. But no one who is acquainted with her character, can ascribe to her *only* selfishness and cunning. Various as are the colours and markings of her fur, as various are her mental, and what we may call moral qualities also. The colour of the fur varies in different individuals, from pure white to pure black, with intermediate tints. The forms in which these colours are arranged are also very various. The markings are striped, tiger-like, or spotted, leopard-like, or waved, as tortoise-shell.* But besides, some cats are clever, while others are stupid. Some are social, affectionate, grateful; others are morose, irritable, revengeful. Some love to sit or lie near one of the family; others slink away or rush away, unwilling to be noticed. Some

* I am informed that tortoise-shell in the male is scarcely ever seen.

are playful, delighting themselves and others with their gambols; while others of the same age dislike locomotion, are what we call demure and sedate, and show even in youth the impassiveness of age. Some of these variations may be attributed to the treatment which they have received; but in many examples they seem to be inborn, appearing as early as anything about them can be noticed. That cats have memory is undeniable; that many have what may be called conscience is equally certain. Often does puss know that what she has done renders her amenable to punishment, and therefore keeps out of sight till she imagines the fault has been forgotten. Attachment to one individual in a family, in preference to another, is often to be seen; and it is not always from what we call selfish or interested motives. I have been informed that a policeman in James' Square was every night attended by a cat in his nightly perambulations; and I know that an excellent landed proprietor in Aberdeenshire is accompanied by his cat in his walks through his property. Some cats show very great dislike to be left alone, and that quite irrespective of expectation of food. But I cannot enlarge on this topic, and only add, that to children the family cat is an unfailing source of enjoyment, merely from its sociableness.*

William Smellie says,—" The language of the cat is more limited than that of the dog. Still, however, it is highly expressive of her feelings and desires. When she wants to flatter, or to solicit favour, she makes a purring noise, accompanied with blandishing movements, and often rubs her sides upon the shins or garments of the person from whom she expects gratification. When a cat happens to be barred out, her mew of anxiety, or her petition to get admittance, is perfectly different from most of her other cries, but seems to be the same as that which she utters when desirous of food." (*Philosophy of Natural History*, vol. ii. p. 422.)

* There is a very learned memoir by Professor Rolleston of Oxford, " On the Domestic Cats, *Felis Domesticus* and *Mustela Foina*, of Ancient and Modern Times," in the " Journal of Anatomy and Physiology," Nov. 1867.

Charles Stewart says,—"The cat varies much in its colours, like all domestic animals. The male has seldom more than two colours, the female often more. It has suffered more from vulgar prejudices than most animals. It is cleanly, and buries its excrement. It is supposed to be deceitful, selfish, and destitute of attachment to mankind; but if we may believe an article in the 'Journal de Médecine' for December 1771, a cat not only showed affection for its master while alive, but watched his body when dead, and for a long time visited his grave." (*Elements of Natural History*, vol. i. p. 83.)

On 4th October 1852, a tortoise-shell kitten, newly weaned, and therefore probably about six or seven weeks old, became an inmate of my house. On 21st February 1853, a Skye terrier about seven weeks old, also came to us. The kitten had been housed in an inverted bee-skep, and the puppy was placed in it also. It was large enough for both; and they showed no disposition to quarrel. They lapped milk from the same dish, and played together on the kitchen floor, without any apparent want of sympathy with each other's feelings. This companionship continued for some months. But at length the increased size of the puppy made him more formidable in a gambol than was agreeable to his playmate, and her agility was required to enable her to escape from his superior strength, by climbing up stairs, which he was very awkward in doing. They still continued to occupy the same nest or lair, till it became too small for both; and, afterwards, his disposition to pull it in pieces soon necessitated its abandonment by both.

After they grew up both continued to live with us, and were constantly in each other's society. They were good friends on the whole; and when on any occasion they quarrelled, it was almost always the cat who was the aggressor. The dog was very peaceable and yielding; indeed, he might be called a coward in her presence. He allowed her to *fuff* at him, and even bore the buffetof her paw, without resisting the affront. She took care, however, to scamper away immediately after giving him a blow. There never was

any permanent interruption of their amity till his death, which took place on 27th October 1864.

I kept a record of her kittenings. They were 25 in number, comprising 78 individuals. The first occurred on 1st December 1853, and the last on 25th December 1864. They are as follows:—

1853, Dec. 1. Three—2 red, 1 black.
1854, Mar. 31. Four—3 black, 1 red.
1855, Apr. 28. Three—2 tortoise, 1 red.
„ July 16. Four—2 black, 1 red, 1 tortoise.
1856, Jan. 17. Three—2 black, 1 tortoise.
„ Apr. 26. Four—2 red, 1 black and white, 1 black and brown.
„ Nov. 16. Three—1 black, 1 white, 1 black and white.
1857, Mar. 14. Four—3 black and white, 1 tortoise.
„ July 31. Three—1 black, 1 red, 1 black and white.
„ Dec. 15. Three—1 black, 1 white, 1 white and brown.
1858, Apr. 26. Two—Both white.
„ Dec. 16. Two—1 nearly white, 1 nearly black.
1859, Apr. 25. Two—Both white.
1860, Mar. 6. Three—2 white, 1 black and white.
„ July 16. Four—2 white, 1 yellow, 1 black.
1861, Jan. 26. Three—1 black, 1 white, 1 black and white.
„ June 9. Four—1 black, 1 black and white, 2 white.
1862, Jan. 14. Three—All pure white.
„ May 17. Three—1 white, 1 black and white, 1 tortoise.
„ Oct. 13. One—Red.
1863, Mar. 9. Four—2 white, 1 gray, 1 red
„ Sept. 8. Four—All more or less tortoise.
1864, Feb. 4. Four—3 gray, 1 reddish (2 of them malformed).
„ June 20. Two—Both black and white.
„ Dec. 25. Three—1 nearly black, 1 nearly white, 1 tortoise.

This record is perfectly accurate as to dates and numbers, although there may be some mistakes as to the colours. The inspection was generally hasty. We always brought up one of the kittens, partly for the sake of the mother, and also because her progeny was valued by our neighbours, as possessing some of her own good qualities. We see that the average of the kittenings was two in the year; the average numbers were between three and four; the colours were—of white 21, black 16, black and white 12, red 11, and yellow 1 (which was probably the same), tortoise 11, grey 4, black and brown 1, white and brown 1. The inequality of the intervals between the kittenings (2½ months being the

shortest, 13 months being the longest) is probably attributable to the season, the weather, or to the health of the animal. The males in the neighbourhood were of various colours; and it could not easily be ascertained which of them was the parent of each group. But there having been only 11 of her own colour out of 78, seem to confirm the observation regarding other animals, that the colour of the progeny does not proceed from the mother.

In regard to the kittenings, a curious observation was made. There was always great restlessness beforehand. She wandered about the house as if in search of a suitable nest. But for a good many hours, whatever had been her relations to the dog, I mean whether they had been friends or not, she manifested attachment to him of the most marked kind. She followed him from room to room, evidently to his great annoyance, and in vain solicited his attention to her. This was renewed for a short time after the kittening. After the entire process had been completed, and the mother with her progeny were quietly settled in their nest, then the dog began his attention to the kittens, watching over them, and licking them with his tongue, as assiduously as if he had been himself the parent. This always continued for several days. These incidents are probably well known to naturalists; but they will excuse me for having recorded them here.

Puss continued for years in very much the same mode of life; a good mouser, a keen hunter of sparrows—occasionally a thief, and then punished as such. She generally came to the dining-room as the dinner was carried in, always expecting, and often receiving, a share of what was at table. She came, however, at other times also, when no food was expected. She occasionally disappeared for a day or two, and returned with slight wounds, for she was a decided fighter. On one occasion (the date of which I have not noticed, but it was probably in 1864), her absence was longer than usual, and she returned in a state of great weakness, very little able to move, and scarcely to swallow. The right eyeball was destroyed, and protruded from the socket.

Her recovery was not expected; but she did recover, probably in consequence of the kind treatment which she received, for she was a favourite in the family, up stairs as well as down stairs. About a month after, a pistol bullet came away from her mouth, and this explained (as we thought) the wound which had been inflicted on her. Although she was restored to health, yet the power of swallowing was considerably impaired; bones or other hard substances were apt to stick in her throat, and on several occasions needed to be pulled away by forceps; although she ate as heartily as before, she had frequently fits of a choking cough, which distressed her much. These latterly occurred during sleep, and roused her up: when the fit was over she went to sleep again.

She gradually became thinner; and as a proof of impaired health, no longer kept her fur in the beautiful condition of which she had been so careful. As another indication of ill health, she showed a fretfulness very unusual to her formerly, but very much like what is seen in invalids among bipeds. She expressed dislike to her kitten, and on its approach growled out her unmistakeable feelings. Soon after, one or more oval swellings were observed in the abdominal walls. I at first supposed them to be abscesses; but they gradually increased in size without becoming softer, and it was evident that they were solid tumours. Her breathing became affected, the respirations becoming as frequent as 40 in the minute. This continued during all the latter weeks of her life. She had cough, and the fits of choking were more common. She did not refuse food, but was capricious as to what she took. She came more frequently up stairs, not so regularly at meals, but at other times, as from a desire to receive help and sympathy. She lay on a knee or lap, preferring it to a chair or rug. During all this time her purring was constant. This is generally considered to be an expression of quiet enjoyment. It was curious to notice it in this case, along with the hurried breathing. She died on 11th February 1866, having lived 13½ years.

Dr Handyside made a careful dissection; and I give the appearances observed by him, which he has kindly communicated to me:—

" I. *Surface of Body.*

" 1. Hypogastric region presented three medullary tumours: *one,* the size of a pigeon's egg, on the line of the linea alba, with a moist ulcerated surface, and involving only the textures over the abdominal fascia; the *second* and *third* smaller in size, and flatter in form, occupying the right and left pubic regions, and firmer in texture than the one above.

" 2. Right eye covered over with a thin opaque film, and the bulk of the globe of the eye less than that of the other side.

" II. *Deeper Parts.*

" 1. *Chest.*—Heart healthy, but its walls thin and flaccid; lungs a mass of ripe and suppurated tubercle; pleura partly adherent.

" 2. *Abdomen.*—Liver of a hard and condensed character, with an orange tinge. A scrofulous nodule, the size of a large pea, projected from the right edge of this organ.

" 3. *Pelvis.*—The right ovary presented on its surface a bloody cyst, the size of a small bean.

" III. The entire muscular and adipose tissues seemed deficient in bulk and firmness. No other morbid or unnatural appearances were recognised."

This examination was quite satisfactory, except in one respect. I had presumed that the ball had penetrated the orbit, and that some trace of its lodgment behind would be observed. None such was discovered; and it has been imagined that the idea of its having been so lodged was a mistake; and that the ball, having been accidentally taken into the mouth along with food, was put out when its presence was uncomfortable. I can only say that the whole circumstances of the case make my idea the probable one

The lapse of two years might suffice to obliterate the traces of the injury.

IV. *On the Nesting of* Cinclus Europæus. By J. Duns, D.D., F.R.S.E., New College, Edinburgh.

As the nest now on the table is, so far as I am aware, the only one of the kind which has been observed, I have thought it might not be uninteresting to show it to the Society.

The nest is double, consisting of two compartments under one roof, divided by a mutual partition. While the roof is one, the depression in the middle preserves the usual rounded appearance of the covering of the single nest over both divisions. The nest was built in eight days. It consists of *hypnums*, intermixed with the dried leaves and stalks of slender grasses. The inside lining is formed of withered beech leaves. This is the favourite lining. When beech trees are not in the immediate neighbourhood of the nesting-place, I have known this bird fly a considerable distance to procure them. The withered leaves of the oak are sometimes used instead.

In four days after the nest was finished, three eggs were dropped! the third on the 22d day of April.

As the place in which it occurred is within gun-shot of a public work, and as many boys frequent the locality, I was led to remove it before the work of breeding was completed, lest it should have been destroyed. The nest was taken from the ledge of a weathered freestone rock, about five feet above the surface of the *Crawhill Burn*, a stream which drains the hills on the east of Torphichen, Linlithgowshire, and joins the *Avon* about one hundred yards to the east of the Avon Steel Work. Ten or twelve years ago, the place was a favourite haunt of the kingfisher, which is now rarely met with there, though the dipper, the sandpiper, Yarrel's wagtail, and Ray's wagtail, are frequently seen.

I ascertained, beyond all doubt, that the nest was the work of one pair of birds. They began by covering the sur-

face of the rock on which it was to rest with a thick bed of well-matted hypnum and grass. The same materials were pressed into the inequalities of the rock which the back of the nest touched. The birds built and carried in turns. When the female was dropping the eggs, the male, as observed on one occasion, took up his abode in the other division. The birds were not so shy as I have often seen the species to be. They continued working while I must have been in full view of them.

After the nest was removed, they began to build again on the same spot, but with less ambition. A single nest was begun in the centre of the spot before occupied by the double one. They had not, however, proceeded far with the work when it was given up; and they ceased for a time to visit the stream at this point.

The instance now referred to is the only one in which I have noticed such a wide departure from the usual mode of nest-building. It is, indeed, not uncommon for this bird to dispense with the roofing of the nest, when, as in rock crevices, it can obtain a natural covering. Even these, however, are exceptional cases.

The dipper is generally said to perch only on stones, but I have several times seen it resting on the low branches of trees overhanging the water. Most observers assert that it never feeds on small fishes, but I have found small minnows, and in one case the fragments of a stickleback, in its stomach, as well as *gyrini*, the larvæ of *phryganeæ*, &c. The dipper's pretty and lively song may sometimes be heard even in severe winter weather. Dr J. A. Smith informs me that he once heard a dipper singing as it floated down the river Tweed perched on a mass of ice.

V. *On Traces of Glacial Drift in the Shetland Islands.*
By C. W. Peach, Esq.

In the summer of 1864, by invitation, I accompanied Mr J. Gwyn Jeffreys, of London, on a dredging expedition to the Shetland Islands. It had long been a wish on my part to see more of that interesting group, from having been much struck with their appearance and productions when hastily passing round them with Sir R. I. Murchison, Bart., on a geological trip some years before. Although Mr Jeffreys' mission was a zoological one, and one into which I entered heartily, I was induced, by a request from Sir R. I. M., to look out for traces of glacial action on the islands we landed on.

The result of these hasty opportunities, and, consequently, imperfect observations, with all their faults, I have thought might be acceptable to the Society, and must, therefore, draw on your kind forbearance for all shortcomings.

I am not aware of any paper on this subject in connection with Shetland, with the exception of one by Dr Hibbert, "On the Direction of the Diluvial Wave in the Shetland Islands," published in the "Edinburgh Journal of Science" for 1831, New Series, vol. iv. p. 85. At that time glacial action was little thought of; and when Dr Hibbert made his survey, he merely noticed a few of the large blocks scattered over some of the islands, and referred them all to the then opinion, that they had been removed from their original beds, and transported by diluvial waves to the places he found them in. Although he mentions seeing transported blocks on several of the islands, from not having made notes at the time of observation, little is to be gathered from his paper. He appears to have had his attention more drawn to them by their size, unusual positions, and the old world stories connected with them, as well as the black agency that was said to have thrown them about. The diluvial wave, he says, had a south-westerly direction. He does not mention grinding and polishing, striæ or scratching. Meagre, therefore, as my story may be, I hope it will

give a little more information, and thus, by adding another stone to the cairn, advance glacial science.

Our first landing was at Lerwick, where little time was spent either then or when returning. In a short walk that I took in the immediate vicinity of the town, at the Bay of Sclate, I found the sandstone on the top of the cliff deeply rutted, striated, and polished; and a little inland, on the side of the famed loch of Clickamin, similar markings. They may be seen also on the opposite side of the bay. The ruts, &c., are all in a north and south direction, with slight deviations to the east and west. The drift evidently came from the north, and may be traced up the valley, as shown by the wide-spread ruin and large blocks scattered all over it, resting on striated and polished rocks. The hills on each side of this valley, and those at the head beyond the docks, bear unmistakeable evidence also of polishing and grinding.

After leaving Lerwick the Out Skerries of Whalsey became our home. The three small islands forming this group lie far out to sea. They are called Gruna, Bruray, and Housay. There is a pretty good harbour here, having two entrances for vessels and boats, and a third into which boats can run when the tide answers. These entrances are triradiate, with the harbour in the centre, sheltered by the three islands from every wind. The islands have been the scene of great grinding, all being more or less rounded into the *Roches moutounnes* form, whether composed of granite, gneiss, quartz, or limestone, all these rocks being intermingled throughout the group. Although corroded by atmospheric action,—the limestone, as might be expected, most deeply cut,—the rounding can be everywhere seen.* Striæ, &c., in the exposed parts, are thus generally obliterated. I was, however, fortunate enough to meet with re-

* To show how abundant lime is in this rock, I obtained living specimens of *Saxicava rugosa* burrowed into it in the Skerries harbour; they were very abundant, and had riddled the limestone beds in all directions. This is rather against the opinion of those who consider that this mollusc could not live so far north, and who stoutly opposed me when I said that they occurred *in situ* at Wick. It was, therefore, somewhat gratifying to me to meet with them so much further north.

cently bared rock at the Mill Cove, on the island of Housay, from which I removed more of the drifted clay and stones, and found ruts, striæ, and polishing in abundance, and as fresh as if only just done. On the highest point of this island I also found deep ruts and scratches, which had not been obliterated from the hard gneiss. All these scratches run nearly east and west, this being the direction of the channel of the two principal entrances to the harbour, by which Gruna is separated from Bruray.

The cliff on the north side of the Mill Cove of Housay is about 100 feet high, and nearly vertical. The sea, in heavy gales, breaks on its top, and tears up the rock, and as well throws up material from the deep. So great is the force, that large blocks are driven far back from the edge of the cliff, and piled up into a semicircular-like wall. Between this wall and the cliff a deep river-like gully is scooped out, down which the water thrown up rushes again to the sea.

The water left in the hollows of this gully is brackish; in it *Enteromorpha* grows. Mr Jeffreys and myself gathered portions of limpets, mussels, periwinkles, rock-whelks, and other sea-shells, amongst the sand and gravel, both in and on the edge of this gully.

A portion of the top of this cliff is higher than the gully, and now beyond the influence of the sea; it is also strewn with proofs of similar action, when in all probability the cliff was not raised so high out of the water. Ridges of stones lie all over the hill, and hang on its rounded sides. The whole of the loose blocks and stones rest on rounded knolls and polished rock, all so polished—evidently by glacial drift—before the burthen was thrown there. This is not the only point on which the terrific seas of this wild spot have left traces of the kind; they are almost on every part, some of the most astonishing and recent are to be seen on the Bound Skerry, an isolated mass of rock on which the splendid lighthouse stands. Mr Stevenson, C.E., has had many of the stones marked, and the changes watched and noted. Those desirous of farther information will do well to consult a paper by that gentleman, printed in the "Proceedings

of the Royal Society of Edinburgh," vol. iv. p. 200. This digression from my glacial story, I trust, is of sufficient interest to be pardoned.

In addition to the glacial markings on the rocks, I met with several deposits of drift, in which rounded, striated, and smoothed stones were not uncommon, some of the deposits being from 12 to 14 feet in depth. Perched blocks, but not in abundance—some of large size—are scattered about, and, with the rounding and smoothing of the face of the rocks, are to be found over all this group of islands.

Unst.—Our next move was to Unst, the harbour of Balta Sound being our head-quarters. Here, too, the effects of glacial action were plainly to be seen. The serpentine rock has suffered seriously; and although much acted on by rain, frosts, &c., the rounded outline of the hills tells plainly of the grinding they have undergone. Ruts and striæ are also rare here. I met with a few on the cliff at Hagdale, in Haroldswick Bay, where there is a thick deposit, composed of clay, in which polished and striated stones, of various sizes, are plentiful. Part of this deposit had recently slipped off the rock, and here the markings were as splendidly shown as if the grating masses had only passed over it a few days before. The direction of the striæ, &c., are nearly W.N.W. and E.S.E. The hills of the Muckle and Little Heogs lie to the north of this spot (Hagdale), and a slope from about 20 feet above the level of the sea hence to the top of the Muckle Heog, rises gradually to the height of at least 500 feet. In this slope lies the famed mine for chromate of iron. On reaching the top of this hill I found the W.N.W. end vertical and polished, to the depth of at least 150 feet, and before it a depression is formed, reminding me much of that in front of Arthur's Seat and Salisbury Crags. The hills to the north of the Heogs slope towards it, and down these, no doubt, the crushing agents came. The vertical or *storm side* of the Heog had evidently resisted a portion of the destroyer, and turned the greater part on its western flank, and thus the main body passed down the valley towards Haroldswick, as evidenced by the greater

destruction there than on the eastern side, towards Balta Sound. The scene from the top of this hill, when looking towards Haroldswick, and then in the direction of Balta Sound, is one that tells of mighty agencies long continued, powerful to crush and grind—so powerful, that the really hard and massive hills of serpentine have been ploughed down to below the sea-level in places, especially at Haroldswick. The sea has since piled up beaches there, through which the water percolates, at each recession of the tide, from the low peaty beds formed in the depression at the back of them. All over Unst the rocks show traces of abrasion, and in many places deposits of drift, in which stones of all sizes, smoothed and striated, occur plentifully. I mention a few of these localities, so that any one desirous of visiting Unst may see them. First, Hagdale in Haroldswick Bay. Balta Sound, especially in the low cliff near the house of Hammer. The haunted burn of Watlea, between Balta Sound and Uyea Sound, and at the latter place on the sea-shore. On the south side of the small island of Uyea, a similar deposit underlies a sandy raised beach, in which stones and large oyster shells, with whelks, &c., and fish bones, are rather plentiful. A similar sandy raised beach is also to be seen in the valley in which the small fishing village of Norwick is built. This also contains sea-shells, such as are found in the seas of the present day. These two raised sandy beaches are at opposite ends of Unst. Large and small blocks—four tons to a few pounds in weight—are scattered about in all directions. With the exception of the raised beaches, I did not find in any of the glacial deposits a single organism. This does not prove that such may not be there, my examination was so slight—want of time preventing me putting them to serious test.*

Thus, then, at both ends and the middle of this interesting group of islands, glacial traces have been found; and from the contour of the other islands, as we coasted along them, appearances told that they had not escaped. I must, however, leave the filling up to others. All the bearings are by compass, no allowance having been made for variation.

VI. *Note of the Colours displayed by a Species of Chameleon belonging to the Genus* Lophosaura *of Dr J. E. Gray.* By John Alex. Smith, M.D. (Specimen exhibited.)

The chameleon exhibited belongs to the genus *Lophosaura* of Dr Gray's Synopsis of the *Chameleonidæ*, published in the "Annals and Magazine of Natural History," vol. xv. 1865. The genus is distinguished by having a series of elongated skinny processes covered with scales, which run backwards from below the chin and throat; in this species, the whole length of the base of lower jaw.

It is apparently the *L. ventralis* (?) of Dr Gray, but the characters of the species are necessarily not very minutely detailed.

It was much emaciated in appearance, and was allowed to dry considerably before putting it into spirits, and the brilliancy of the colours are still retained to a considerable extent. They are certainly strikingly different from the usual dingy bluish grey or dirty white which generally characterises all the specimens of the chameleons preserved in spirits.

The whole upper surface of head is concave, and covered with tubercles, and the projecting occiput has a central ridge, and is narrow and rather pointed. Two patches of flattened scales lie behind the orbit, on sides of occiput and temples, and are divided by a ridge running back from the orbit.

Its occipital crest is relatively more abruptly prominent and higher than the *Lophosaura ventralis* figured in the monograph already referred to.

The back is denticulated along its ridge, and there is a series or belt of rather pointed, closely-set scales, varying in size, running along each side of the central line, and this is continued in a similar way along the whole upper half of the tail; the toothed ridge disappearing towards its extremity. Three or four series of larger rounded scales run somewhat parallel to one another along the sides of the body, the largest series running backwards from behind the shoulder to the root of the tail. A belt of larger sized light-coloured scales

runs backwards from the chin along each side of the base of loose fringe, and terminates at the sides of the neck. The lower parts of the abdomen and the under surface of the tail have the scales small and equal; and there is no central crest. The legs and feet are thickly studded externally with larger rounded scales, but they are small and equal on the inner surface.

Colour.—The scales of this creature resemble a beautifully-coloured piece of elaborate mosaic work. The *head* has the muzzle of a dark green, edged with black, and spotted with vermilion; the orbits and cheeks of a beautiful vermilion-tinted flesh colour. The top of the head is dark green, spotted with flesh colour; the occipital plates flesh coloured, and the projecting ridges of the head dark green, pointed with black. The chin and throat are pale blue and green, studded with flesh colour and vermilion, the green becoming darker behind the loose fringes under the chin and throat, which have a belt of light blue at their roots, and are spotted with flesh colour and light green. The fringe consists of fourteen portions or segments; the first three are single, the fourth and fifth consist of double flaps of skin, and the remaining ones are simple or single.

The ridge of the back is of a bright yellowish green, spotted with dark green scales, the conical tubercles along the ridge ending in dark grey. There is next a narrow longitudinal band or belt of pale blue, with larger scales and spots of red and vermilion colour, running along the sides of the back; and below this a broader longitudinal belt of reddish flesh colour, running from the temple and shoulder to the base of the tail, studded with several rows of larger scales of a light red colour. Below this belt again is another of blue dashed with green, ending in yellow green at the shoulders, and studded also with larger red scales. Under this is a broad belt of flesh colour, studded with larger and darker red scales, below which is a belt of lightish green and blue and dirty white; another belt of dirty white and greenish forming the central part of the belly below.

Legs.—The legs are bright yellowish green outside, studded

externally with a series of larger scales of a darker green, and others lighter. The inside of the legs is greenish grey.

Tail.—The tail above is yellowish green, with lighter and darker spots of yellow and blue; and below it is greenish grey.

The specimen was fed with flies, and brought alive from the Cape of Good Hope to Leith, by Mr Adam Brown, engineer, and died only a few weeks ago.

An artist friend has kindly made a sketch in water-colours of the chameleon (now exhibited), thinking the bright tints of the creature would soon fade, but they are still in a great measure retained; it was very unusual, so far as Dr Smith was aware, to see them still remaining to so great an extent after the death of the chameleon.

Length of head to extremity of elevated crest, $1\frac{1}{4}$ inch.

Length from snout to anus along abdomen, $3\frac{3}{4}$ inches.

Length from anus to extremity of tail, $3\frac{3}{4}$ inches.

Greatest depth of body, $1\frac{1}{4}$ inch.

The fringe measures $\frac{12}{20}$ of an inch in length, and its longest lobes $\frac{3}{20}$ of an inch in depth.

The specimen is probably a female.

VII. *Ornithological Notes:* (1.) Aquila chrysäetos. (2.) Pastor roseus, *Young.* (3.) Passer domesticus, *and* Turdus merula, *white varieties.* (Specimens exhibited.) By John Alex. Smith, M.D.

(.1) Aquila chrysäetos, *Golden Eagle.*

A very fine specimen of a male golden eagle was exhibited. It was shot on the 9th January last, on Rinevy Hill, Glenshee, Perthshire. The bird showed the general dark plumage, and the white base of the tail, characteristic of the *young bird.*

(2.) Pastor roseus, *Temm, the Rose-Coloured Pastor.*

The bird is probably a young male. It was shot on 28th October 1865, at Sound, near Lerwick, Shetland Islands, while feeding with a few common starlings. An adult female, now preserved in the Lerwick Museum, was shot on 23d May 1865, at Maryfield, Island of Brassay, near Lerwick;

on dissection, some of the eggs were found considerably enlarged. No male was seen in the neighbourhood. The bird is an occasional straggler in Britain. Only a few instances of its occurrence in Scotland have been recorded.

This bird has the immature plumage of the young bird. Upper parts light brown; some of the feathers a little darker in the centre; wings and tail darker brown, feathers all edged with grey or whitish, especially outer edges of wing feathers; eyelids whitish. Below, dirty white. Bill rounded above; upper mandible dark brown, lower mandible lighter and yellow at base. Feet yellowish brown. Claws brown. Wing—first primary very short and pointed; second primary longest in wing, and rest diminish gradually in length.

The following are the measurements of this young specimen, as compared with that of the adult female :—

	Young Bird.	Adult Female.
Length from point of bill to extremity of tail,	$8\frac{11}{16}$	$7\frac{6}{8}$
Length from tip to tip of extended wings,	$14\frac{5}{8}$	$14\frac{6}{8}$
Length of wing from flexure, . .	$4\frac{7}{8}$	$4\frac{6}{8}$
Length of bill along upper mandible, .	$\frac{7}{8}$	$\frac{6}{8}$
Length of tarsus, ...	$1\frac{2}{8}$	$1\frac{1}{8}$
Length of middle or third toe, . .	$1\frac{3}{8}$	$1\frac{2}{8}$
Length of claw of third toe, . . .	$\frac{5}{16}$	$\frac{7}{8}$

This young bird was carefully examined by Sir William Jardine, Bart., and he states, "It is a rose-coloured pastor; and I have one in nearly the same state, but with some black feathers appearing."

(3.) There was sent for exhibition an almost pure white finch, a so-called Japanese sparrow, recently brought to this country;—the bird closely resembled the well-known "Java sparrow," of which, indeed, the specimen seemed merely to be a white or perhaps albino variety. A nearly pure white common sparrow—the primaries and tail feathers alone retaining the usual colour; and a specimen of the male blackbird, *Turdus merula*, the greater part of the head and throat being pure white. Both these birds were recently shot in the neighbourhood of Edinburgh.

Wednesday, 25th April 1866.—Professor JOHN DUNS in the Chair.

The following Donations to the Library were laid on the Table, and thanks voted to the Donors:—

1. Geological and Natural History Repertory, Nos. 10, 11, 12, with Proceedings of Geologists' Association. 1866.—From the Geologists, Association. 2. The Canadian Journal. No. LXI., January 1866 — From the Canadian Institute, Toronto. 3. Observations on arrested Twin Development. 1866. By P. D. Handyside, M.D.—From the Author.

The following Communications were read:—

I. *The Pearls of the Ythan, Aberdeenshire.* By the Rev. JAMES BRODIE, Monimail, Fife.

These mussels are, of course, of various sizes, and are found sometimes in the running stream, and sometimes in the pool. I found them most abundant in those places where the bottom consisted of a softish sand, with a gentle current flowing over it. The pearls are embedded in a filmy substance that occupies the space between the valves and the body of the animal. There is not a pearl, even of the smallest size, in every mussel; on the contrary, I have frequently gathered more than a hundred and have not found anything whatever to recompense my trouble.

I remarked that, generally speaking, the shells collected in the streams, where they had been exposed to the tossing of the winter floods, most abundantly rewarded the gatherer's toil, and that those which were distorted and bore the marks of having been broken by violence, were those in which pearls were most frequently found. These circumstances led me to conclude, that the pearl is produced by some piece of broken shell or extraneous matter getting embedded in the filmy substance to which I have just referred, and by the irritation which its presence produces inducing around it a deposit of the same substance as that which lines the shell. I was led to regard the formation of the pearl as the result of an accident rather than as the effort of a disease, as many have supposed. . . . . The patronage of the Queen has made the Scottish pearl to be so much more

highly prized than it used to be, that some one, more favourably situated than I am, may perhaps be induced to follow out my experiment, and establish a colony of *natives* for the manufacture of pearls. The Scottish pearl very seldom has the peculiar colour which is so much prized in those that come from the East. The Ythan pearls, when I used to gather them, were generally of a silvery-white, with what we may describe as a slight shade of blue. Sometimes they had a yellowish tinge, and I have seen some with a faint but very beautiful trace of purple. When pearls lying together in the same shell are found, some white and some brown, when we find them with one side white and the other dark, it is evidently very difficult to determine the circumstances on which their colour depends. I cannot leave the subject without adverting to the fact, that if we may trust tradition, an Ythan pearl is one of the gems that now adorns the British crown. Many years ago, before the coinage of Scotland was assimilated to that of England, two farmers were returning from market. When they came to the banks of the Ythan, one of them dismounted, the other retained his seat, and holding the bridle in his hand stooped forward to let his horse drink. While in this position, he observed near the place where his companion was standing a very large mussel, and called to him, " I say, Tam, rax in the crucket end o' your stick, and get me that muckle clam-shell; it will be a famous thing for our Kate, whan she scrapes her sowans' pot." The comrade did as he had been requested, and the clam was consigned to the farmer's capacious pocket. On opening it when he got home, he found that it contained a large and beautiful pearl. This he carefully preserved, until an opportunity should occur of getting it disposed off to advantage. Some time after he had occasion to go to London, and took the pearl with him. While there, he went to one of the principal jewellers in the city, and showing him the gem, he asked what he thought of it. "It is very beautiful; it is one of the finest pearls I have ever seen. Is it for sale?" " Ow aye, if you will gie me a lang eneuch price." After some further talk, the farmer said,

"Fat dae ye say to a hunner pun'?" He meant pounds Scots. "A hundred pounds, sir!" exclaimed the jeweller. "It is a beautiful pearl, a very beautiful pearl, but a hundred pounds is a very large sum; and"—— "Aweel," said the Aberdonian, who saw from the manner in which the jeweller spoke that if he stuck to his demand it would be granted, "that's the price, tak it or want it." After a little hesitation the bargain was made, and the farmer got an hundred pounds sterling, instead of the "hunner pun" Scots, equal to eight pounds six shillings and eightpence, which he asked when he went into the shop. The jeweller afterwards sold the pearl to the king.

Dr J. A. Smith reminded the Society that Mr Alexander Bryson read a paper at their meeting in February 1860 "On the Structure and Formation of Pearls," an abstract of which was published in their Proceedings. Mr Bryson's views were quite in accordance with those of Mr Brodie. He might also mention that specimens of shells with pearls artificially produced by the Chinese might be seen in the Museum of the Society of Antiquaries.

Mr C. W. Peach said it was a common statement in the Highlands, that pearls were not to be got there since the old system of keeping black cattle had been abolished, and he believed there was a good deal of truth in this, although he would not explain it as the Highlanders might be inclined to do. He believed the herds of cattle wading in the streams would crush and injure many of the mussels, and, as Mr Brodie remarked, cause them in this way to form pearls within their shells.

II. *Farther Observations on the Boulder Clay of Caithness, with an additional List of Fossils.* (Specimens were exhibited.) By Charles W. Peach, Esq.

At your meeting of the 25th February 1863, a paper of mine was read on the above subject. At the close, regret was expressed that "the author had not been a little more explicit in his details of the clay-beds, and the exact locali-

ties in which the various organisms described by him were found." I am sorry that, however willing to comply with the above request, space will not permit me now to do more than mention a few of the localities whence the organisms were taken, they are so many; for, as I stated in my former paper, the "boulder clay may be traced all over Caithness." Where excavations have been made for any purpose, and rivers and burns have acted on these deposits, good sections are to be met with, and *in all* organisms in greater or less abundance are to be found;—at Wick, on both sides of the harbour, and up the river to the Loch of Watten. The cliff at the South Head is also rich in clay and organisms.

The Burn of Milton, near Wick, where a new cut for the water was made a few years ago, has also proved a rich mine; the cutting exposed many roots of trees of pretty large size, and many rootlets, in two or three places in its course; some of these had penetrated the very hard clay to the depth of four or five feet. As well as the wood itself, several hard sandy tubes and root-like objects were in the clay. These had taken the place of some of the decayed roots and rootlets, as might be seen by small strings of the wood in many of these sandy masses; they were red and hard, evidently caused by the iron which had cemented the sand together. The trees to which these roots and rootlets belonged had evidently grown on the banks of a loch which once existed there. All traces of the trunks are lost, and the places on which they grew are covered with a thick deposit of peat-like matter, no doubt drifted, and by which the loch was filled. The course of the ancient stream in its windings, with its pebbly bottom, may be seen in various places in the newly cut banks. One of the largest pieces of vegetable matter showed a coniferous structure. These trees were evidently of a later age than the boulder clay. The Burn of Haster all the way up shows fine sections; and as the water of the burn, with frost and rain, are continually acting on them, fresh faces are often exposed, and fine collections may be gathered. Here I first got *Foraminifera* in a pretty little nest of sand; since that, at this spot, and

all the other localities mentioned, in the hard clay itself. The Burn of Strath, to beyond the "Crowner's Garden," is equally rich in clay and organisms. In one very small spot beyond the last-named place, I got many nice specimens of *Melobesia*, some of them very little rubbed. Can this be an old sea bottom? I regret that I was never able to get there again when the river was low, to work this out. The Burn of Watten deserves a good search. The high cliffs over Scrabster are thickly capped with clay, and the upper face of the rock on which it rests is smoothly polished and deeply grooved; such is the case with the whole of the rocks on which the clay is deposited. Hence to Thurso, and all along the river to far inland, the clay is abundant. At "Geize," old John Busby, in 1802, "found blue clay-marl in great plenty intermixed with marine shells," and also at Dalemore. What a pity it is that this interesting discovery was lost sight of so long!

From Thurso, all along the side of the Pentland Firth to Mey Castle, Canisbay, John o' Groats, Duncansbay Head, thence to the Burn of Freswick, Keiss, and to Wick, thence to Lybster, Forse, Latheron, Latheron Wheel, Dunbeath, &c., in all these places, and many more localities, I have found organisms in greater or less quantities. Although the clay is not uniform in texture, being finer or coarser, in some places almost free from stones, and these of small size, in others—even at short distances apart—it is full of stones, many of large size, and in all places polished and grooved ones are far from rare. The clay itself is always hard and rough to the touch. For the present, although considered objectionable by many, it will be well to retain the name of boulder clay for the deposit. I do not object to its being called glacial, for it evidently was in the first instance derived from glaciers, but forced to sea and deposited by icebergs stranded on the Caithness shores. These icebergs, when first launched into the sea by the ice-streams from the glaciers, picked up some of the sea-bottom, with its organisms; and when on their voyages, wherever they touched, they added to their burthen by picking up more

organisms, &c.; and when finally stranded, quantities of the mud, sand, stones, and organisms of the Caithness shores were mingled with them. As the icebergs dissolved the burthen was dropped in a pell-mell manner. The ice protected the materials, and prevented the sea from levelling and arranging them, and giving the deposit a stratified appearance it otherwise would have done could it have acted on it. The gradual dissolving of the bergs gave time to the clay to solidify, and thus it was preserved when its carrier and protector was no more. Once firm, especially in deep water, little injury could be done to it. It suffered most in shallow water, and when exposed to the frosts and wet of winter; and, although not so much affected by summer sunshine and showers, even then portions of it would doubtless be carried away. The story of the voyaging and gatherings of the icebergs is well told by the contents of its left burthen; for Crag, as seen by its shells, &c.; Gault, Chalk, and Green Sand by the flints, corals, and *Foraminifera*, with portions of the Chalk, both hard and soft, some so soft that it may be used for writing with; Lias and Oolite by the belemnites, ammonites, fossil wood, septaria, &c.; Silurian by its metamorphic limestone, quartz, and other rocks; Cambrian by its gneiss, &c., granite, porphyry, &c.; and then the abundance of the Old Red Sandstone torn up and mingled with all the others by the ponderous icebergs, as they grated and thumped before finally resting, form a curious but suggestive collection. The organisms are entombed in a stubborn and hard material; it has, however, been made to give up its ancient dead, and to show that at the time of its formation life was as abundant as now, and that, with few exceptions, the same species found in it are now living in the present seas, many around our own shores, some few in the Arctic Seas only, and probably one or two may be extinct—I say may be, from having been taught great caution by so many of those said to be extinct, having been from time to time dragged from ocean's depths by our active dredgers. I feel now it is best to say probably extinct. Several species of *Foraminifera* (not mentioned

in the list) were detected in the boulder clay, which came from the chalk formation; these, with the great quantity of other chalk material, also in the boulder clay, connected with the abundance of chalk flints which are met with all over the surface of Caithness, as shown in a paper of mine read to the Society some years ago, give room to suspect that in all probability the chalk formation, and that pretty largely developed, as shown by its widespread ruins, was not far distant from Caithness, and it would be well to collect all the evidence possible on this desirable and interesting subject.

The fragmentary state of the organisms proves that they could not have lived and died where now found, as no two valves were found united (with the exception of two very small *Anomias*) amongst the hundreds of specimens taken out of the clay. Theré is no doubt that these minute shells were sheltered in hollows in the rock masses to which they were attached when living, and, when these masses were removed, held fast by their strong plug, and only became loose when this had decayed; and thus these delicate and frail shells escaped destruction. Mr J. Anderson, of Wick, got a nice group of young *Balani*, in a pretty good state of preservation, attached to the fragment of a shell. These being such rare instances, I have thought it right to mention them.

Many of the organisms are microscopic, and were washed out of this stubborn clay by myself and Mr J. Anderson, and it is thus that the list has been so greatly extended. The most abundant shells are *Cyprina islandica*, *Astartes*, *Tellina solidula*, *Turritella communis;* the latter occur in a pretty perfect state, and from microscopic size to more than two inches in length, and in such abundance that, in three walks up the Burn of Haster, I got more than eighty specimens, and did not take all I saw. However, it would be well not to think such great riches are always to be had, for at times scarcely any specimens are to be got. A few of the others are pretty frequent, whereas ***Purpura lapillus, Trochus Ziziphinus, Patella vulgata, Mytilus edulis, Mya truncata, Littorina littorea, Ostrea edulis,*** and other littoral and shallow-

water shells, are very rare indeed, represented many of them by single specimens only.

In taking leave of the subject, permit me to mention the kindness of the following authorities for their valuable and ready assistance in their various departments. First, to Mr J. Gwyn Jeffreys, who has again and again examined parcels of Mollusca for me; Mr H. B. Brady, of Newcastle, the Foraminifera; and his brother, Mr G. S. Brady, of Scarborough, the Entomostraca; and my old friend Mr Alder, of Newcastle,* for much advice. To each and all of these I am under great obligations. None of these gentlemen are to be held responsible for any errors that may creep into this paper or lists; unfortunately, with all care, they will occur, and they belong to me only.

List of Organisms.

Brachiopoda.

Bivalves.	*Ranges.*
Rhynchonella psittacea, . . .	Arctic Seas.
Pecten islandicus, ...	Arctic Seas.
Ostrea edulis, ...	Iceland, Norway, Naples.
Anomia ephippium, *var.* squamula,	Iceland, Norway, Ægean.
Mytilus edulis, ...	Polar Regions and Ægean.
modiolus, . . .	Behring's Straits, S. of England.
Crenella decussata, ...	Arctic Seas, Yorkshire.
Nucula nucleus, ...	Norway, Ægean.
sulcata, ...	Norway, Ægean.
Cardium edule (of the Bridlington Beds), ...	Iceland, Norway, Ægean.
exiguum, . . .	Norway, Ægean.
Cardium fasciatum, . . .	Norway, Azores.
Leda pernula, *var.* baccata, . .	Norway and Sweden.
pygmœa, ...	Spitzbergen, Skye.
minuta, ...	Arctic Seas, South of England.
Lucina borealis, ...	Iceland and Norway, Sicily.
spinifera, ...	Norway, Canary Islands.
Astarte sulcata, *var.* Scotica, .	Norway, Ægean, Canary Islands.
borealis, *Jun* , . . .	Polar Regions, Kiel Bay.
Venus gallina, ...	Iceland and Norway, Sicily.
lincta, ...	Iceland and Norway, Ægean.
casina, ...	Norway, Canary Islands.
ovata, ...	Norway, Ægean.

* Since the above was read, death has taken this estimable naturalist away.

Donax vittatus,	Norway, Ægean.
Solecurtus candidus,	Shetland, Canary Islands.
Saxicava Norvegica,	Iceland, Norway, Dogger Bank.
Mya truncata,	Spitzbergen, Bay of Biscay.
Cyrtodaria siliqua,	An Arctic species, found by Dr Rink fossil in Greenland.

Univalves.	*Range.*
Trophon truncatus,	Norway, Yarmouth.
Fusus antiquus,	Arctic Seas, Bay of Biscay.
Nassa incrassata, *var.*,	Norway, Sicily.
Buccinum undatum, deep-water, var.,	Norway, Bay of Biscay.
Bela pyramidalis,	
ginnaniana (nebula),	North Africa, Madeira, Canaries.
Mangelia Lefroyi,	Sweden, Ægean.
nebula,	Norway, Sicily.
pyramidalis,	Arctic Seas.
Natica pallida (Grœnlandica),	Icy Cape, Yorkshire.
affinis (clausa),	Polar Regions, Bergen.
nitida, *var.*,	Norway, Sicily,
Cerithiopsis costulata,	Shetland, Spitzbergen.
nivea,	Shetland.
Odostomia albella,	Norway, Sardinia.
acicula,	Norway, Ægean.
Turritella terebra,	Norway, Ægean.
(communis, ungulina),	Norway, Ægean.
Lacuna divaricata (vincta),	Greenland, Gulf of Gascony.
Rissoa parva, *var.* interrupta,	Norway, Canary Islands.
Litorina litorea,	Greenland, Lisbon.
obtusata,	Iceland, Norway, Vigo.
Trochus Grœnlandicus,	Polar Seas, Skye.
Vahlii,	Arctic Seas.
Chiton cinereus,	Greenland, Ægean.
Tornatella fasciata,	Norway, Ægean.

Crustacea.

A fragment of shell of.

Entomostraca.

Cythere concinna.
Cythereis Dunedinensis.
Cytheridæ papillosa.
punctillata.

Cirripedia.

Balanus crenatus.
Verruca stromia.

Annelida.

Sipunculus Bernhardus? Two specimens—one in a Dentatum shell, one in Natica helicoides.
Spirorbis granulatus.
Sandy tube, part of a Pectinaria?

Echinodermata.

Ophiocoma rosula, spines of.
Echinus neglectus, do.
Several pieces of plates and spines of at least two more species.
Spatangi, do. do.

Polyzoa.

Salicornaria.
Hippothoa divaricata.
Lepralia Peachii, *var.* labiosa.
Lepralia unicornis.
Cellepora pumicosa.
Tubulipora hispida.
Crisia denticulata.

Foraminifera.

Biloculina ringens.
Triloculina oblonga.
Quinqueloculina seminulum.
subrotundata.
Trochamminia incerta.
Dentalina communis.
Vaginulina legumen.
Vaginulina linearis.
Nodosaria raphanus.
Cristellaria rotulata.
Polymorphina lactea.
compressa.
Globigerina bulloides.
Cassidulina lævigata.
Truncatulina lobulata.
Rotalia Beccarii.
Soldarii.
Polystomella crispa.
striatopunctata.
arctica.
Nonionina asterizans.
depressula.
Pearl of Mytilus edulis.
Fish bone, joint of fin ray.

Summary.

		SPECIES.
Brachiopoda,		1
Mollusca, univalves,	26	53
bivalves,	27	
Crustacea,		1
Entomostraca,		4
Cirripedia,		2
Annelida,		3
Echinodermata,		5
Polyzoa,		7
Foraminifera,		22
Carry forward,		98

	SPECIES.
Brought over,	98
Pearl,	1
Fish bone,	1
Total of additions,	100
List presented in 1863,	42
Total of both Lists,	142

Of which some are British, a few Arctic only, all are Scandinavian and Arctic.

III. *Note on a New Species of* Equus *from the Zambezi, Africa.* (Drawings were exhibited.) By ADAM WHITE, Esq., late of the British Museum.

Mr White gave some details of the discovery and character of this so-called new species of *Equus,* but considered that we must wait for more information before it could be held as settled that it really was specifically distinct from the Zebra, or Burchell's Zebra. The Society was indebted to Mr Lawrence for his being able to exhibit a beautiful painting in oils, representing this new animal in its native wilds.

IV. *Recent Additions to the Coleopterous Fauna of Mid Lothian.* (Specimens exhibited.) By W. R. M'Nab, Esq.

Through the kindness of my friend Mr David Sharp, I am enabled this evening to lay before the Society a list of 103 species of Coleoptera new to the Edinburgh fauna. They have been mostly taken by Mr Sharp, and the names are on his authority. In some few instances I have also taken the insect myself, and shall therefore add the locality where I have taken the beetle to those supplied to me by Mr Sharp.

Mr Murray's Catalogue has been taken as the guide, and the species in this list are either not in Mr Murray's catalogue, or else not mentioned by him as having been taken in the Edinburgh district.

The majority of Coleoptera included in this list are Brachelytra (65 species), which are proportionately more largely represented in Scotland than any of the other sections.

1. Notiophilus palustris, *Dufts.* Braid. D.S
2. substriatus, *Waterh.* Stockbridge. D.S.
3. Patrobus clavipes, *Thoms.* Pentlands. D.S.
4. Anchomenus Ericeti, *Panz.* Polmont. D.S.
5. Thoreyi, *Dej.* Duddingston. D.S.
6. Amara curta, *Dej.* Corstorphine. D.S.
7. Trechus obtusus, *Er.* Common.
8. Bembidium Mannerheimii, *Sahl.* Common.
9. monticulum, *Sturm.* Banks of Esk. D.S.
10. Colymbetes bistriatus, *Bergst.* Aberlady. D.S.
11. Hydroporus ovatus, *Sturm.* Banks of Almond, Broxburn. D.S.
12. ferrugineus, *Steph.* Water of Leith at Ravelrig. D.S.
13. Haliplus obliquus, *Fab.* Aberlady. D.S.; Burntisland. D.S. W.R.M.
14. Helophorus arvernicus *Muls.* Common.
15. Hydræna gracilis, *Müll.* Midcalder. D.S.
16. Cercyon lugubre, *Payk.* Duddingston. D.S.
17. Ptenidium punctatum, *Gyll.* Under sea-weed on shores of Firth of Forth. D.S.
18. Agathidium convexum, *Sharp.* Corstorphine Hill. D.S.
19. Meligethes seniculus, *Er.* On Echium flowers. North Queensferry. D.S.
20. Cryptophagus umbratus, *Er.* Braid. D.S.

21. Cryptophagus pubescens, *Sturm.* Braid. D.S.
22. Atomaria nigriceps, *Er., Murr. Cat.* Common.
23. diluta, *Er.* Corstorphine. D.S.
24. nana, *Er.* (nigriventris, *Steph.*) Kinghorn, Burntisland. D.S.
25. analis, *Er.* (Wollaston, Edinburgh.) Braid and Blackhall. D.S. W.R.M.
26. basalis, *Er.* (Wollaston, Edinburgh.)
27. Georyssus pygmæus, *Fab.* Kinghorn. D.S.
28. Aphodius obliteratus, *Panz.* Cramond. D.S.
29. putridus, *Creutz.* Carnethy Hill. D.S.
30. fœtens, *Fab.* North Queensferry. D.S.
31. punctato-sulcatus, *Sturm.* Braid. D.S. W.R.M.
32. Ceuthorynchus hirtulus, *Schüp.* Aberlady. D.S.
33. Quercicola, *Fab.* Corstorphine. D.S.
34. Otiorhynchus muscorum, *Br.* Corstorphine. D.S.
35. Tanysphyrus Lemnæ, *Payk.* Duddingston. D.S.
36. Sitones puncticollis, *Steph.* Braid. D.S.
37. Apion pallipes, *Kirby.* On *Allium ursinum.* Eskbank. D.S.
38. Donacia aquatica, *Linn.* Aberlady. D.S.
39. Autalia puncticollis, *Sharp.* Braid. D.S.
40. Phlœopora reptans, *Gr.* Common.
41. Ischnoglossa corticalis, *Steph.* Duddingston. D.S.
42. Callicerus obscurus, *Gr.* Comely Bank. D.S.
43. Calodera riparia, *Er.* Davidson's Mains. D.S.
44. Homalota currax, *Kraatz.* Banks of Almond. D.S.
45. velox, *Kraatz.* Banks of Almond. D.S.
46. fragilicornis, *Kraatz.* Banks of Almond. D.S.
47. pavens, *Er.* (sulcifrons, *Kirby*, *Steph.*) Banks of Almond. D.S.
48. vestita, *Gr.* Burntisland. D.S. W.R.M.
49. subrugosa *Kiesenw.* Aberlady. D.S.
50. intermedia, *Thoms.* Aberlady. D.S.
51. Oxypoda ruficornis, *Mannerh.* Braid. D.S.
52. longiuscula, *Gr.* *Passim.*
53. annularis, *Mannerh.* Braid. D.S.
54. hæmorrhoa, *Mannerh.* Braid. D.S.
55. aterrima, *Waterh.* Blackhall. D.S. W.R.M.
56. Leptusa fumida, *Er.* Broxburn. D.S.
57. ruficollis, *Er.* Broxburn. D.S.; Blackhall. D.S. W.R.M.
58. Aleochara algarum, *Fauv.* Burntisland. D.S. W.R.M.
59. Phytosus nigriventris, *Wat. Cat.* Longniddry. D.S.
60. Gymnusa variegata, *Kiesenw.* Duddingston. D.S.
61. Tachinus pallipes, *Grav.* Corstorphine. D.S.
62. laticollis, *Grav.* Braid. D.S.
63. rufipennis, *Gyll.* Pentlands. D.S.
64. Bolitobius inclinans, *Grav.* Cramond. D.S.
65. Mycetoporus nanus, *Grav.* Braid. D.S.
66. punctus, *Grav.* Duddingston. D.S.

67. Philonthus politus, *Fab.* *Passim.*
68. ebeninus, *Grav.* Corstorphine and Braid. D.S.
69. corvinus, *Er.* Aberlady. D.S.
70. micans, *Grav.* Aberlady. D.S.
71. nigrita, *Nord.* Duddingston. D.S.
72. cinerascens, *Grav.* Duddingston D.S.
73. vernalis, *Grav.* Aberlady. D.S.
74. Quedius fulvicollis, *Steph.* Duddingston. D.S.
75. humeralis, *Steph.* Braid. D.S.
76. Lathrobium longulum, *Grav.* Davidson's Mains. Duddingston. D S.
77. Stenus melanopus, *Marsh.* Falkirk. D.S.
78. latifrons, *Er.* Falkirk. D.S.
79. gonymelas, *Steph.* Davidson's Mains. D.S.
80. nigritulus, *Gyll.* Corstorphine. D.S.
81. nitidus, *Steph.* *Passim.*
82. picipennis, *Er.* Davidson's Mains. D.S.
83. brevicollis, *Thoms.* Pentlands. D.S.
84. tarsalis, *Ljungh.* Duddingston. D.S.
85. fulvicornis, *Kirby.* In moss, Botanic Garden. W.R.M.
86. Bledius arenarius, *Payk.* Aberlady. D.S.
87. fuscipes, *Rye.* Aberlady. D.S.
88. Evæsthetus scaber, *Grav.* Aberlady. D.S.
89. Haploderus cælatus, *Grav.* Corstorphine. D.S.
90. Oxytelus maritimus, *Thoms.* Shores of Forth. D.S. W.R.M.
91. Trogophlœus elongatulus, *Er.* Duddingston. D.S.
92. Ancyrophorus omalinus, *Er.* Banks of Almond. D.S.
93. longipennis, *Fairm.* Polmont. D S.
94. Thinobius longipennis, *Kiesenw.* Banks of Almond. D.S.
95. Acidota cruentata, *Mannerh.* Comely Bank. D.S.
96. Olophrum fuscum, *Er.* Davidson's Mains. D.S. Blackhall D.S. W.R.M.
97. Lathrimæum unicolor, *Marsh.* *Passim.*
98. Omalium nigriceps, *Kiesenw.* Botanic Garden. W.R.M.; Pentlands. D.S.
99. riparium, *Thoms.* Shores of Forth.
100. vile, *Er.* Broxburn. D.S.
101. cæsum, *Grav.* *Passim.*
102. Eusphalerum primulæ, *Steph.* Polmont. D.S.
103. Micropeplus margaritæ, *Du V.* Comely Bank. D.S.

V. *Alteration of Sea-Level in the Island of Tiree.* By Mr Alexander Scott, Portobello.

Having recently read, through the public press, several papers on the change of sea-level on the coasts of Scotland, I am induced to offer the following:—

Some years ago, while resident in the island of Tiree, in

the Hebrides, being engaged in the erection of the lighthouse at Skerryvore, under the superintendence of the late Mr Alan Stevenson, civil engineer, I had opportunities of observing the mode of fishing for sillocks and other small fish, very abundant there at certain seasons. It is not the mode of fishing, so much as the appliances made use of by the natives for fishing, to which I wish to direct attention.

On the south end of the island there is a rocky headland called Hynish Point, much resorted to by the natives for rod and hand-net fishing. The east face of this rock is naturally adapted for such exercise, in having several ranges of natural steps or stages upon which the fishers take up their position. Several of these stages, about half tide up and upwards, have circular holes, in the shape of a bowl, cut out of the hard gneiss rock, into which the fishers put shell-fish, which they bruise with a round stone till they are like pulp. Handfulls of this pulp are thrown into the sea, to decoy the fish close upon the rock, and then the fish are taken, either by the hook or net, in great quantities.

When the tide has risen to the lowest stage, the fishers have recourse to the next stage higher up the face of the rock, and so on as the tide rises; and on several of these places also holes are excavated for the shell-fish thus prepared.

I have observed that considerably higher up the face of the rock there are stages with holes cut into them, similar to those below, but which are much too high to be of any service at the present day as fishing stances, as they are a great many feet beyond practicable reach of the sea.

The fact of these holes in the upper parts of the rock being of the same shape, &c. as those at present in use, shows that the mode of fishing is not only a very old one, but, in my opinion, it is also a strong proof of a change having taken place in the sea-level, and that this process may still be going on for aught we know to the contrary.

VI. *Ornithological Notes.* 1. Buteo lagopus (*Rough-legged Buzzard*); 2. Tetrao urogallus (*Capercailzie, female assuming male plumage*); 3. Saxicola œnanthe (*Wheat-ear*). Specimens were exhibited. By John Alexander Smith, M.D.

1. *Buteo lagopus.*—The rough-legged buzzard, a fine old female. It was killed on the 17th April 1866, near Rachan House, Peeblesshire.

Head and neck yellowish white, with longitudinal streaks of brown on middle of feathers. Back light chocolate brown.

Base of tail white; distal extremity dark brown, tipped with lighter brown or whitish.

Below, chin and breast yellowish white, with longitudinal streaks and spots of dark brown.

Broad band of dark brown across lower part of breast.

Thighs yellowish white, spotted with brown; tarsi feathered to the junction of the toes.

Length from point of bill to extremity of tail, 23 inches; length of wing from flexure, 17 inches; irides pale yellow.

The prevalence of light colour in this specimen shows, I am inclined to believe, the great age of the bird.

It is one of our occasional visitors, and is generally seen in the spring or autumn.

2. *Tetrao urogallus.*—The capercailzie, *a female assuming male plumage.*

The length of the bird from the point of bill to the extremity of tail, is 27½ inches, rather longer than usual for the female, the tail being, like that of the male, large, long, and rounded. The head, neck, and upper parts of body are grey, the brown plumage being all tipped with grey; the back of reddish brown, with darker spots of brown; and the lower part of back brown, mixed with grey. Wing coverts are dark brown, mottled with darker brown, as in the male. Below, the broad brown bar across the breast of the female, in this bird shows the feathers tipped with the bright glossy green colours of the male.

The tail feathers are long, and dark grey or nearly black, as in the male, and the feathers are also slightly tipped with

white; the long upper coverts are reddish brown, banded with brown, and broadly tipped with grey above, and the long terminal ones are tipped with white. The under parts of the body are brown, largely tipped with grey and white. Feathers of the thighs are greyish; feet and claws dark brown.

Length of wing from flexure, 12 inches. The bill is of a light horn colour, especially at the sides and tip.

The bird is probably an old female; and the ovaries appeared to be very small or atrophied.

It was shot in the neighbourhood of Dunkeld, in the end of March.

Mr Small, bird-stuffer, George Street, has kindly sent along with the bird fine specimens of the male and female for comparison.

The only other specimen of this variety which I have seen, or heard of in this country, was one killed in the same neighbourhood, and exhibited to the Society, in December 1862. It was not quite of such a length as the specimen now exhibited; which, I am glad to say, has been acquired for our valuable Museum of Science and Art.

Mr Yarrell copies a figure of this variety in his "British Birds," as having been noticed in Scandinavia.

3. There was also exhibited one of our regular and earliest summer visitors—the *Saxicola œnanthe*, the wheat-ear. It was taken about the middle of the month of March, on shipboard out in the Atlantic, about 500 miles from our shores, having been probably carried away by the easterly winds when on its northern migration.

VII. *Notes on the Gold-field of Ballarat, Australia.* By ADAM SMITH, Esq., Ballarat. Communicated by Dr JOHN ALEX. SMITH. (With exhibition of specimens of rocks, maps, &c.)

The following notes were written without any idea of their being published, in reply to the queries of a relative, asking for some information about the Ballarat gold-field. They are simply extracts from a private letter which ap-

peared to contain such general information as might interest the members of the Society, especially as it was accompanied by specimens of the rocks and clays and maps of the district. Mr Smith writes:—

"The greatest difficulty I have experienced has been to get a man who knew the geological names of the different strata; but as your letter suggested that I should send home some specimens of the various strata, I shall do so by M'Niell, who goes by this mail, and this will relieve me from the difficulty. By a map of the Ballarat mining district, which I shall also forward, you will see accurately laid down by the various mining surveyors (and tinted blue) the various leads that have been worked and traced, and the quartz reefs that have been discovered (coloured red). You will also observe on the map the course of the Yarrowee creek, which runs along the foot of the high land on which Ballarat West is built.

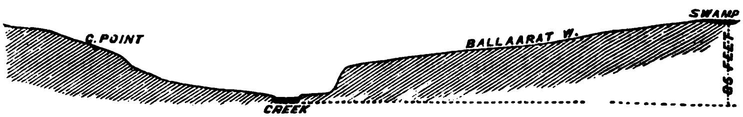


Fig. 1.—Diagram section of ground on which Ballarat West is built.

"There is no section on the map, but as nearly as possible the section from the Yarrowee up to the swamp will be as shown in the annexed diagram, and you will get the correct distance from the map. By this you will see that, instead of the swamp being lower than the town, it is situated on the highest part of Ballarat; it is about eighty-five feet above the level of the creek. You will also observe, that far the greater number of the leads which have gone to form the main or Golden Point lead, have taken their rise on that side of the Yarrowee on which Golden Point is situated, the principal ones being the chain of leads beginning at New Chum and One Eye, and receiving many small ones from the east, or rather north-east, of the Golden Point, and White Horse ranges, called on the map Yuille's range. After receiving all the leads from the range, it forms a

junction with the Eureka lead which rises up in the ranges at Little Bendigo, and collects many small leads on its way down. When joined, these leads, or rather the lead, takes its course away towards the high land on which the town is built, and winds away below the town as far as it has been traced into the Koh-i-Noor Company's ground, where it is at this present time almost incredibly rich.

"After following the lead up to the edge of the basaltic plateau, or, more correctly speaking the sloping ground, on which Ballarat is built, and driving as far as they could drive, it became necessary to sink shafts in the bluestone, and as the farther in the plateau the rock became deeper, the companies amalgamated, and conducted their operations on a larger scale than they had done in their shallow sinkings. From Mr Davidson, mining surveyor, I obtained the following report of the various strata met with in sinking the shafts of

The Great Redan Extended Company.	ft.	*Great Republic Company.*	ft.	*Nelson Gold Mining Company.*	ft.
Surface soil,	5	Surface soil,	3	Surface soil,	5
1st bluestone rock,	82	1st rock,	130	1st rock,	80
Greenish clay,	8	Brown clay,	18	Marly clay,	10
2d bluestone rock,	82	2d rock,	30	2d rock,	95
Red and black clay,	40	Fine sand,	12	Marly clay,	8
3d bluestone rock,	35	Yellow clay,	12	3d rock,	100
Red clay,	5	Fine sandy drift,	12	Sandy drift,	8
Drift,	35	Clay and drift,	53	4th Rock,	80
4th rock,	30	Gutter reached at	262	Wash dirt,	386
Clay,	5				
Headings and drift,	12				
Reef,	12				
	351				

By these you will see that the sinkings vary considerably. The Extended has got four rocks or beds to cut through, the Nelson four, and the Republic only two. Some companies have got three rocks, others only one, according to their position. You will observe, in the sinking of the Great Extended, that the lowest part of the sinking is in reef. Well, this reef is what they never go below, in alluvial gold mining; it is always the bottom—the surface of the reef, is the bottom. It is a soft clayey slate (I shall send a specimen of it), in which, in certain parts of this

gold-field, numerous veins and reefs of quartz are found; and in sinking a shaft, if they know accurately the position of the gutter, which they can find by boring at intervals all round, they sink, if the extent of their claim permits them to do so, away from the lead or gutter, and by this means perhaps avoid one thickness of rock, and then they drive for the gutter. I will try to illustrate my meaning by a rough sketch (fig 2). The lowest part of

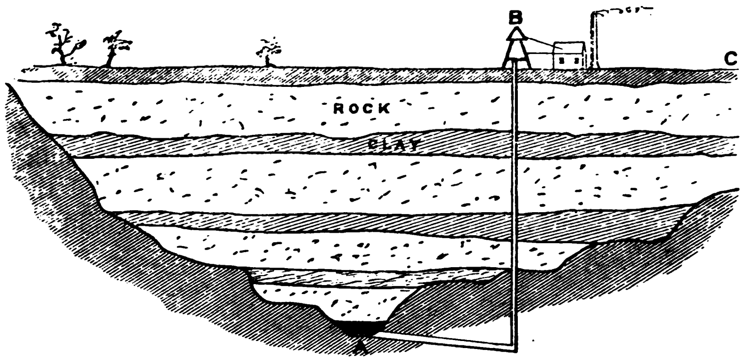


Fig. 2.—Diagram to illustrate the varying rock strata cut through by different mining companies. It represents at the top, the natural surface and soil; below this the dotted bed represents the 1st rock come to, next the shaded bed represents a bed of clay, then another bed the 2d rock, next a bed of clay, below it the 3d rock, next a bed of drift, and below it the 4th rock, under which lies the gutter; the lowest shaded portion forming the floor of the whole, being the slaty reef, as it is termed—the original surface of the country.

the diagram, marked A, is the gutter containing wash dirt. These gutters are old water-courses which at one time existed on this continent, and they have worn themselves down in the soft slaty reef which was then the earth's surface.

"This reef sometimes crops out to the surface on this gold-field, and at other times, as represented by my diagram, has been worn down by old world floods till it is only reached between 350 and 400 feet in the bottoms of these gutters. By sinking a shaft at B, the company would

escape the fourth rock, and would save much expense, as rock blasting at such a depth costs a great deal. If they were to sink at C, they would escape two rocks, but would have farther to drive, and might be troubled with want of air. My sketch will show you that where four rocks exist, the fourth is filling up some high-sided gulley in the ancient river bed; and the third even may be so too, or the second, as the case may be. These claims, or mining companies already referred to, are all on very deep leads, in fact, the main lead, as it is supposed to be, the Republic excepted, which is on the Inkerman gutter, and is, to use a mining phrase, shallower ground. In these gutters the water is still flowing with a slow but perceptible current. The gutter is always richest in gold where the reef at each side slopes up. If the course has not been worn much down below the old level of the country, the gutter or lead is not so rich, as one can easily understand. This would seem to indicate clearly that these gutters are the receptacles for the gold which has rolled down into them from the quartz reefs and veins which they have intersected in their course. The soft slaty surface has been easily worn into water-courses, and, doubtless, heavier rains at one period than prevail now would wear down the surface very fast. The wash dirt consists of quartz, gravel, and sludge from the reef. You mention having seen a piece of petrified wood from one of the Ballarat gutters. We sent some home to Dr Smith by Mr Laidlaw, which you can see. And this morning I walked up to the Koh-i-Noor claim, and got a few specimens of lignite, of which there are a good many among the wash dirt. They are very nice specimens, and show the texture of the wood, which I think has been gum, just the same timber that grows here now.

"No one knows yet whether the two main leads of Ballarat, the Golden Point and the Inkerman, trend south or west; and each theory has its warm advocate in exact proportion to the amount of interest that said advocate has in claims through which he expects either lead to come. Golden Point, where last worked, is heading south; the Inkerman

runs round the edge of the swamp with a general westerly course where worked by the Southern Cross Company, but has lately taken a bend, and now inclines south also. If they do come together, I think it will be a long way down from where they are worked now. There is a bluestone under the swamp, just the same as any other part of the plateau, a few feet from the surface. The Royal Saxon Company have followed the National lead (a tributary of the Inkerman), a long way below it. The Southern Cross have also got wash dirt below the swamp, and on the other side the Durham Company have struck a gutter, as also on a third side have the Great Republic, so that they will soon see what is below it, hemmed in as it is. As your memory

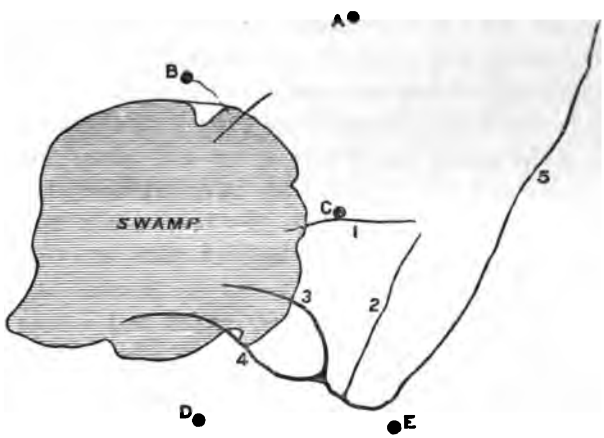


Fig. 3.—Diagram of the turn of several gold leads round Ballarat swamp.

does not serve you very well about the swamp and the leads in its neighbourhood, the accompanying rough sketch, fig. 3, failing my getting an extended map of the leads, will show you their position. The Inkerman lead (5 in diagram) rises in Devil's Gulley beyond the Black hill, receives some tributaries in its early course, and at the Royal Saxon claim (E) receives nearly together the Ballarat mill-lead (2), and the National lead (3). The Southern Cross Company (D) are working the Inkerman below the swamp, and that is all

the length that it has been traced. The Republic (C) have got wash dirt at their shaft, on what I believe is called the Wheat-sheaf lead (1); and the Durham Company (B) are working wash dirt in their ground, I suppose on the same lead from which the Essex (A) have been getting their gold for some time. As my sketch is from recollection, it can only be an approximation to correctness, or scarcely so.

"And now as to the theory in your letter about the formation of the gold-field of Ballarat and other gold-fields, I think, by pipeclay, you mean what miners here call reef, below which no gold has ever been got. I think it quite possible that this may have been an ancient sea-bottom, but think also that when it was elevated, by whatever convulsion, and exposed to wind and rain, that it would waste down very rapidly, as it does now when exposed to the air. Gold is so very heavy that it only travels a very little way, and needs a considerable declivity to do that.

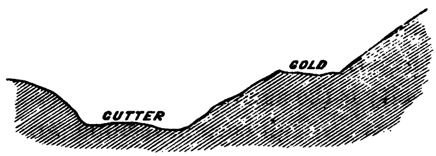


Fig. 4.—Diagram showing section of a gutter with level shelf on one side, on which gold is often found.

"The leads with sloping sides (which indeed all of them have of course), but with long sloping sides, have most gold in them.

"Many reefs at sides of the gutters pay well for working, especially if they have a formation, such as I have shown in sketch fig. 4, with level places on the side, occasionally the larger pieces may roll down into the gutter, but these shelving places catch a deal of gold, and are consequently worked by many companies after the lead is exhausted. Therefore, I think, that by the wearing of the beds of these old rivers, the quartz veins and quartz reefs, through which they forced their way, supplied the gold which is in their bottoms or gutters, or leads as they are now called. One theory

as to the origin of quartz and gold is, that at one time the earth's surface was very much cracked, and that melted silica, containing metal in minute division, was projected up from the interior and filled these cracks, forming quartz reefs and veins; that the metal got cooled in its ascent and formed gold; that most of it, from its volatility, rose to the surface and became deposited there; but lately many things have occurred to shake this theory. One of them is, that the yield of gold does not decrease as they go downwards in working the reef. A Government commission went round the gold-fields last year making all inquiries on this very subject, but all mining men here dispute their verdict, which was to the effect, that the lower you went the purer the quartz became. I saw two mining managers at Clunes lately, who told me their experience went to the contrary, and I have asked many Ballarat men, who agree with the Clunes managers. Another circumstance which has given rise to a totally different theory is, that at Smythesdale a piece of petrified wood was discovered on which was a deposit of iron pyrites and gold. The favourite theory now is, that electricity is the agent which produces gold, and that it requires to pass through certain feeding grounds to be so produced; but I have never seen a written statement of this theory, although, if there is one, I shall try and get it for you.

"The general map of the Ballarat district will show you the way in which the leads all run, and is on this account, I think, very interesting. It includes the gold-fields also of Clunes, Creswick, Sago Hill, Smythe's, Brown's, Linton's, Carngham, Lucky Woman's, Italian's, Buninyong, and Hard Hills. From Ballarat to Clunes the basaltic plain extends, which begins at the side of the Yarrowee. It goes far beyond Clunes on the north side, and how far south I do not know, and over all the way to Burrumbut, with occasional cropping out of hills and other formations, as for instance, quartz in the Creswick gold-field; and as the farthest mines are not more than half a mile from the edge of this plateau, it seems to me that the basaltic plain covers

an inexhaustible gold-field, and if so, Ballarat has a future. It is well known that there is deep ground in some parts of this plain, as it has been prospected by boring, but time will be required to develop it. One noticeable feature in all the Ballarat leads has been their richness. The gold is there, if they can only get at it, and so rich as to repay in many instances almost any expense.

"Every man, on payment of one pound per annum, has a right to mine for gold on crown lands, and in a proclaimed gold-field can build himself a house on crown land, enclose a quarter of an acre, and no one disturbs him. But it can only be his so long as he possesses it. If he leaves it, another man can take it up, and the crown only recognises the possessor. To get possession of it he applies to the mining surveyor, who gives him a written notice to post on it for seven days, stating who has applied for it. If any one opposes it, it is done by lodging objections with the surveyor, who then hands the case over to the warden to adjudicate upon. All applications for mining are made in the same way. If dissatisfied with the decision of the warden, the case can be carried to the Court of Mines, then to the Supreme Court, and lastly, to the Judicial Committee of the Privy Council at home. The warden and surveyors are appointed by Government. The warden is warden of crown lands and of the gold-field, and settles all minor disputes about mining, and arbitrarily all crown lands settlement cases which are not connected with gold, issues licenses to saw-mills and splitters, &c. The surveyors make surveys of all land applied for mining purposes, and of workings below ground, keep a registry of all transfers of land, and mortgages of mining property in crown lands. For instance, if a man makes over his house, on crown land, as security for a debt, instead of a regular lawyer's document, you get a mortgage ticket from the surveyor, pay him half-a-crown, and it is done. They also make regular returns to Government of the amount of quartz crushed and its yield, number of miners and engines at work, &c. Besides these functionaries, there is a Mining Board, consisting of one repre-

sentative from each mining division, who make the by-laws under which the gold-field is worked. They regulate the size of the claims allowed to each man in a company, and sit in judgment on all land that the Government puts up for sale. If considered auriferous, the Mining Board object, or petition I believe is the form, and it is withdrawn. They are elected by persons who hold a miner's right. I ought to mention, that each man who holds a miner's right has a right to vote for a member of Assembly, but he must pay one shilling to get himself registered for that purpose under this new Act; formerly it was not so. I enclose a piece of a leaf from the surveyor's book of one of the Mining Board's by-laws [the leaf was exhibited]; it will show you the way they regulate the size of the frontage claims. If the sinking does not exceed 220 feet, each man is allowed 36 feet of the gutter (lineal feet), and so on in proportion. Frontage claims mean those claims which have so many men's ground along a lead. If a party sink a prospecting shaft and discover a lead, they are entitled to the number of men's ground that are in the party, along that lead, wherever it goes; hence the many lawsuits; as when gold is discovered (below ground) it is impossible to tell where the lead comes from, and where it is going to. Besides the frontage system, many mining companies take up block claims (getting leases from Government), which they believe to be auriferous, in as large blocks as they can get hold of without interfering with their neighbours, and this is the favourite plan now.

"The Mining Boards of the different gold-fields manage most of the local legislation, as each gold-field has its own peculiar circumstances which are best understood by local men.

"The specimens of strata sent were got at the Koh-i-Noor new shaft. They were the only *authentic* ones I could get."

[The Hand Specimens sent and exhibited consisted of—

1. "Black reef above third rock."—A dark coloured compact clay shale.

2. "Third rock."—A fine-grained felspathic trap.

3. "White clay below third rock."—A white coloured stiff clay.

4. "Drift below white clay."—Consisting of bits of brown clay and angular fragments of quartz.

5. "Brown clay, below the drift."—A stiff and almost compact brown clay.

6. Fossil wood or "Lignite," as it has been erroneously named. This specimen (apparently a portion of the trunk of a tree) is irregularly flattened in shape, and measures 3½ inches across, by 1½ inch in greatest thickness. There is a coating of fossil wood round the outside of the specimen, in a brown or partially carbonised state, showing, however, a distinct wavy and fibrous structure, especially on the rounded side, probably the outside of the trunk, the bark being removed. The central part is filled with a fine-grained felspathic trap, similar in general appearance to the specimen of the third rock. Attempts were made to prepare sections of the wood for examination by the microscope, which its friable character rendered very difficult. Little information, however, could be gained beyond its woody tissue, the great breadth or size of its medullary rays, and the apparent presence of resin or bitumen among its fibres. The specimens were also examined by Mr John Sadler, of the Botanical Society, who stated he could find no traces of coniferous structure, and that the great size of the medullary rays reminded him more of the wood of our genus *Quercus* (oak) than any other wood.

The specimens were given to Professor Duns for the Museum of the New College.]

Thanks were given to the office-bearers. The Society then adjourned to the commencement of next Winter Session.

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